Electronic Storage No.:
HK L00874
Worldwide Scientific Affairs

Electronic Storage No.:
HK L0ec875
Worldwide Scientific Affairs

FINAL REPORT

Consultancy Study for Indoor Air Pollution

in Offices and Public Places in Hong Kong

Agreement No. CE 14/95

Reference : **IAQ632-5.DOC**

Client : **Hong Kong Government**
Environmental Protection Department
Air Services Group

Date : **October 97**

For and on behalf of EHS Consultants Limited:

Prepared by : **Original Signed**

Mr. Dave Ng
Senior Consultant
Dr. Lai Wan Yee
Consultant

Checked by : **Original Signed**

Dr. Sarah Liao
Managing Director

G:\iaq\REPORT\FINAL\Iaq632-5

PM3006517296

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Acknowledgement

EHS Consultants Limited wishes to thank all those who have allowed their premises to be used for the on-site survey. Those who agree to have their names disclosed and hereby acknowledged:-

Bachy Soletanche group
Consumer Council
David C. Lee Surveyors Ltd.
Hong Kong Tourist Association
Hong Kong Land
Jardine Technical Services
Kowloon Motor Bus Co. (1933) Ltd.
Kumagai Gumi Co. & Ltd.
Mass Transit Railway Corporation
Millionfull Co. Ltd.
Sino Land Company Ltd.
Sun Hung Kai Properties Limited
Swire Properties
The Chinese Manufacturers' Association of Hong Kong
The Hong Kong Electric Group
Volkswagen Asia-Pacific Ltd.
Wayfoong Properties Ltd.
Wing Hang Bank

A vote of thanks is also given to all our sub-consultants who have painstakingly worked with us under an extremely tight schedule. Without everyone's dedication and ingenuity, the project would not be what it is now.

PM3006517297

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

EXECUTIVE SUMMARY

1. Background

In the Second Review of the 1989 White Paper on Pollution issued in November 1993, the Government recognised the existence of potential health risk and problems associated with indoor air pollution. As an initial step to address the issue, an 18-month Consultancy Study on Indoor Air Pollution in Offices and Public Places was commissioned in October 1995. The Study was carried out by EHS Consultants Limited and managed by a Steering Group chaired by the Environmental Protection Department. Other members in the Steering Group included the Planning, Environment and Lands Bureau, Architectural Services Department, Electrical and Mechanical Services Department, Labour Department and Department of Health.

2. The Study

The Study was to characterize and quantify the indoor air pollution in office premises and selected public places in Hong Kong, assess the causes of the pollution problems, and recommend the most suitable control strategy. It comprised (a) questionnaire survey, (b) field sampling and laboratory analysis, (c) statistical analysis of the results, (d) study on the practice of other countries. The Study also identified the measures to mitigate indoor air pollution and prepared a draft Code of Practice on the management of IAQ, made proposal on the IAQ objectives, produced a mathematical model to predict the levels and exposures of common indoor air pollutants. It also proposed the approach and action on control of IAQ in residential premises.

2.1 Questionnaire Survey

The questionnaire survey was to gauge the indoor air quality (IAQ) situation of offices and public places in Hong Kong and the associated medical symptoms, and to facilitate subsequent correlation analysis with the characteristics of the occupants/ premises and other surveyed parameters. The questionnaire design was based on the US National Institute for Occupational Safety and Health (NIOSH) with slight modifications to suit local conditions. It consisted of two parts: a telephone survey on 2,000 respondents and an on-site survey on 1,183 occupants of 40 selected office premises. The occupants' perception of the IAQ in their workplace was gauged by expressions of satisfaction, and by calculating a Building Symptom Index (BSI) based on responses to questions about medical symptoms which would go away after leaving the workplace. Building occupants' perception is traditionally considered an important indication of sick building syndrome, given the health symptoms associated with it.

2.2 Detailed Measurements

The sampling protocol for field measurement was based on the US Environmental Protection Agency's BASE (Building Assessment Survey and Evaluation) study and modified as necessary to cope with the local constraints. Detailed monitoring and laboratory analysis of 40 offices was conducted between March and October 1996. To assess the extent to which air quality problems are due to seasonal variations, a longitudinal study covering summer and winter months for five out of the 40 office premises was made. A pilot study of IAQ in public places, which looked at selected samples of twenty restaurants, eight shopping malls, five cinemas, two wet markets and selected concourses/platforms of the Mass Transit Railway, was also conducted.

2.3 Statistical Analysis

Extensive statistical analysis was made to establish the degree of correlation between occupants' reported perceptions about IAQ and the tangible, measurable parameters. The consultants also looked into the correlation between perceptions and specific medical symptoms.

2.4 Other Countries' Practice

The Study also surveyed the relevant legislation, regulations and current practices on the control of IAQ in eight developed countries, namely Japan, United Kingdom, USA, Australia, South Korea, Singapore, Canada and Sweden. The study of the experiences in these countries provided the background information which is particularly useful in formulating the strategy to institutionalise IAQ for Hong Kong.

PM3006517298

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

3. Major Findings

3.1 Questionnaire Survey

The questionnaire survey found that some 32% of the respondents were dissatisfied with the IAQ of their workplace. This figure is comparable to that reported in similar studies by the World Health Organisation (WHO).

3.2 Detailed Field Measurements

In the field measurement survey, carbon dioxide was the pollutant most often violated the international standards on IAQ: in the summer survey, 37.5% of offices had, over an 8-hour period, a mean carbon dioxide level exceeding 1,000 ppm [1]. These excessively high levels of carbon dioxide were found to be caused by the high occupancy density in Hong Kong and inadequate ventilation. Indeed the fresh air content provided by the air-conditioning systems in 90% of the office buildings was found to be insufficient and well below the minimum requirement of 7.5 litres per second per occupant specified by the revised ASHRAE Standard 62-1989R of the American Standard for Heating, Refrigeration and Air-conditioning Engineering.

As a result of inadequate ventilation, the bacteria count in terms of "colony forming units per cubic meter" (cfu/m^3) was higher than the recommended level of 1,000 cfu/m^3 in 20% of the offices included in the summer survey. Fungal levels exceeded the recommended level (500 cfu/m^3) less often but toxigenic species such as *Aspergillus versicolour* and *Penicillium aurantiogriseum* were found in over 10% of the premises. The dust collected in these premises all contained quantities of glucan and endotoxin (which cause inflammation and come from fungi and bacteria respectively) as well as dust mite allergens. These are thought to contribute to the allergic reactions experienced by many people in indoor environments.

Formaldehyde levels were also found to be above the WHO guideline of 100 μg/m^3 in 32.5% of the offices in the summer survey. Formaldehyde emissions were associated mainly with chipboard, plywood using urea formaldehyde as an adhesive, and some coating polymers used to treat the surface of upholstery. Apart from formaldehyde, other volatile organic compounds were found in levels below the WHO guidelines or less than 5% of the threshold limit values (time-weighted average) used in industrial workplaces.

There were four premises where the levels of organic compounds, such as toluene, xylene (o-, m- and p-) and benzene, were exceptionally high. This was found to be due to the use of thinner in painting and woodwork during the redecoration of offices on the same floor as the offices where the sampling was taking place. This shows the importance of monitoring and controlling activities which may affect other occupants sharing the same floor and/or the same ventilation system.

3.3 Statistical Analysis

In the statistical analysis, the results showed significant correlation between the occupants' perceptions and measured parameters of IAQ including temperature, humidity, air change per hour, and levels of carbon dioxide, carbon tetrachloride, dichlorobenzene, bacteria and fungal counts. There was also a positive correlation between occupants' perceptions and 21 medical symptoms. For other parameters such as formaldehyde, toluene, xylene (o-, m- and p-) and trichloroethylene, the correlation, although significant, showed a reverse trend. These findings suggest that, while occupants are aware of environmental conditions such as the level of carbon dioxide and temperature, their sensitivity to important pollutants such as formaldehyde and organic solvents associated with thinners (decoration work), may be overshadowed by the "feel good" factor associated with newly decorated premises. This shows the importance of conducting both questionnaire surveys of occupants and sophisticated analytical tests of volatile organic compounds and formaldehyde: the former, to obtain a good indication of the general indoor environment, and the latter to ensure a thorough investigation of IAQ.

There was no significant correlation between levels of pollutant in indoor air with outdoor air except for respirable suspended particulates, with indoor air at a lower level as dust was trapped by filters in the ventilation

---

1 *"1000 ppm" is the standard recommended by the American Standard for Heating, Refrigeration and Air-conditioning Engineering (ASHRAE) - the body responsible for setting internationally recognised standards in indoor air quality*

PM3006517299

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

system. Pollutants which showed higher levels indoor from outdoor had indoor emission sources, such as carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, radon as well as bacteria and fungal counts. This demonstrates the importance of controlling the indoor air quality which can effectively reduce exposure of occupants in an indoor environment.

By carrying out a detailed survey of 40 carefully selected representative office sites and the 2,000 questionnaire surveys covering at least 800 identifiable buildings, it was possible to make a projection of the likely indoor air quality of the entire office building stock in Hong Kong within reasonable statistical confidence. The evidence of levels of indoor air pollution above international standards in many of the offices studied demonstrates the need for public guidance on how to manage the indoor air quality in these premises and recommended standards. A summary of the levels of indoor air pollutants found in the office buildings studied is provided in Table 1.

3.4 IAQ in Public Places

The pilot study of IAQ in public places found specific problems such as failure to comply with existing regulations or presence of pollutants at levels which violated internationally accepted guidelines. Table 2 provides a summary of the findings for public places.

For restaurants in general, the current smoking control measure is insufficient and efforts should be made to require segregation of ventilation systems to effectively control the entrainment of tobacco smoke to no-smoking areas. Adhering to a set of code of practice designed for this purpose or administrative requirements on smoking policy would yield positive improvement to the air quality indoor in such premises. For restaurants with naked fire in the dining area, the local exhaust provisions should be required to achieve IAQ objectives of nitrogen dioxide and carbon monoxide.

The results of the survey of the Mass Transit Railway (MTR) showed that IAQ at the MTR concourses and platforms during normal operational conditions was comparable even with the health/comfort-based IAQ objectives recommended in this Study for non-industrial and public places. The concentration of carbon dioxide inside train compartments during peak-hour period was high due to extremely crowded conditions, but it was still within the guideline for subway design in the USA.

3.5 Study on the Practice of Other Countries

The study showed that other countries are devoting resources to establishing standards, providing mitigation measures, and public education initiatives with the aim of improving indoor air quality. Of the advanced Asian countries, Japan has already introduced an indoor air quality control and monitoring requirement under the Ordinance of Office Sanitation, Singapore issued the Indoor Air Quality Guideline in 1996, and South Korea has an Indoor Air Quality Management Ordinance in the pipeline. In the west, the USA took the lead in proposing an Indoor Air Quality Bill under the Occupational Safety and Health Administration (OSHA) in 1993 but has so far failed to secure political agreement to the Bill. In the UK the issue also suffers from lack of support from political leaders. The Nordic countries, however, have been more active with Sweden and Finland adopting stringent codes to control IAQ under their respective ventilation laws.

In all these countries, there are already many regulations which in some way affect indoor air quality. That is also the situation in Hong Kong. Table 3 gives a list of existing responsibilities of government departments that are relevant to IAQ.

4. Recommended Measures for Improving IAQ

4.1 Code of Practice

The Consultants have prepared a draft Code of Practice (CoP) to help the practising professionals to ensure acceptable IAQ with reference to the established practice of other countries, including Canada, USA, Finland, Sweden, Australia and Singapore. It is recommended the final CoP should be finalized after

PM3006517300

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

consultation with the building developers, property managers and building professionals. It will serve as the cornerstone of the indoor air pollution control programme and should include the following essential elements:

(a) A clear definition of the responsibilities of the different groups of people who potentially have a direct or indirect impact on IAQ,

(b) A comprehensive list of technical measures to be implemented, and

(c) The indoor air quality guideline or objectives to be achieved and maintained.

4.2 IAQ Guidelines/Objectives

The Study recommended the use of the Finnish model of setting three levels of IAQ objectives complemented by the classification of office types according to their abilities to attain these objectives should be considered. In the system, the lowest level is to meet the basic health-based standard; and the two higher levels allow the owners to aim at optimal health outcomes when more resources and technical capabilities are available. The result of having greater prestige and higher values of the premises serves as the major incentives for the owners to pursue for better IAQ. The Study showed that the lowest level should have already been achieved in almost 65% of the office premises of Hong Kong.

4.3 Control Strategies

The Hong Kong Government's initiative to improve IAQ in Hong Kong premises will be taken forward by a special Management Group to be chaired by the Environmental Protection Department who was the convenor of the IAQ study. The main function will be to co-ordinate the implementation of a system of control based on the various options proposed; to review progress using indicators such as complaint cases; and to recommend action to make the scheme work more efficiently wherever necessary.

The Study made a very detailed evaluation of suitable systems for institutionalising the control of IAQ in Hong Kong. Four options were identified, viz.

(a) Option A: Self regulatory
(b) Option B: Making use of existing legislations
(c) Option C: Amendment to existing legislations
(d) Option D: Statutory control under new legislation

For Option A, the CoP will be issued as guidelines for the professionals and building management on a self-regulatory basis. This option has the advantages of a fast-track programme, flexible in actual implementation and with little resistance anticipated from the affected parties. The effectiveness of implementation, however, cannot be guaranteed.

Option B makes use of the provisions of certain existing regulations by administrative means such as through the drafting of Technical Memorandum, to make reference to the CoP. Amendment to those regulations is not required. Option C is to amend the existing regulations or licensing provisions of Chapters 123, 132 and 172 for the enforcement of the CoP. Both Options B and C provide the Government with the enforcement power but require certain lead time and much effort in coordinating the various control bodies. Option D involves the introduction of a new and comprehensive legislation to provide the most effective coverage for IAQ enforcement. However, the legislative process will be lengthy and that considerable resource implications and restructuring should be anticipated.

Other than Option D, the other options can be adopted in various combinations for implementation. The Management Group should determine the best option and oversee all the related activities and progress and review the situation in three years' time.

4.4 Residential Premises

The indoor air quality of residential buildings is also an important area, but, from a practical point of view, can only be controlled on a voluntary basis. The government should initiate public education to promote the importance of maintaining good practice related to indoor air quality. Public awareness campaigns are essential to bring the issue of IAQ to the attention of the general public. It would be useful to establish a contact/information centre to which questions and requirements for measurements could be addressed.

PM3006517301

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

5. Recommended Further Studies

In light of the findings from this Study, the consultants recommended a more detailed study on the economic evaluation of the impacts of IAQ which may take the form of a government initiated cost-benefit analysis of improvement in IAQ. There are obviously costs in upgrading 'hardware' set up (such as ventilation) and 'software' management system in enforcement, monitoring, licensing and complaints investigation related to IAQ. However, the consultants in its preliminary economic analysis has illustrated that such cost will be more than offset by the gain made in the reduction of medical cost and regaining the loss in productivity due to 'sickness' at work.

The consultants also recommended further research into indoor air quality problems in educational institutions which carry out a variety of activities from laboratory work to physical exercise, and medical institutions where special control of gases, chemicals and micro-organisms is necessary. Institutions with susceptible groups including schools, hospitals and homes where the young, the aged and the sick are present, should also be considered as cases for further study.

6. Conclusion and Way Forward

The Study concluded that indoor air pollution in Hong Kong is very similar to that of other developed countries. The air quality in about one-third of the office buildings was perceived as unsatisfactory by the occupants and has violated WHO or relevant overseas standards.

The approach adopted so far in controlling IAQ in Hong Kong is through establishing basic air quality standards and ventilation requirements. There are already statutory provisions to require buildings, workplaces and specified public places such as restaurants and cinemas to comply with basic ventilation and air quality standards but these responsibilities are split among a number of government departments. A more comprehensive mechanism to strengthen the control over IAQ may be warranted subject to a review of the situation by the Management Group in three years' time. For the interim, a comprehensive CoP giving a set of IAQ objectives and good practices on the management and enhancement of IAQ has been developed for use by the related professionals and building management. The Study recommended that the provisions of certain existing regulations should be further utilised to address the issue of indoor air pollution by making reference to the CoP.

Improving IAQ has been shown to bring economic benefits through higher worker productivity and lower medical costs. The assurance from the Government to actively maintain acceptable IAQ standards in Hong Kong buildings is an important element for international community to decide to work and live in Hong Kong. IAQ also plays a part in Hong Kong's competitiveness as an international business centre in the region. With a concerted effort and a sound institutionalised scheme of control, the IAQ of our buildings can be made more acceptable and provide a healthy environment for people to live and work in. Government buildings should take the lead for voluntary control and that should be good news for business, public and government alike.

PM3006517302

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 1: Summary of Indoor Pollutant Levels Recorded from the 40 Offices During The Summer Survey

Pollutant	IAQ-O (8 hrs)	Unit	High	Low	Mean	SD	50 percentile	75 percentile	95 percentile
CO	10,000	$\mu g/m^3$	1958.91	233.02	854.25	456.57	744.12	1102.4	1809.78
CO_2	1,000	ppm	1816.03	506.33	958.63	276.56	866.94	1082.74	1506.25
HCHO	100*	$\mu g/m^3$	176.98	20.86	71.28	41.70	63.92	105.52	132.24
NO_2	150	$\mu g/m^3$	49.63	4.20	18.97	10.92	15.42	25.26	39.28
O_3	120	$\mu g/m^3$	124.62	27.48	37.32	20.25	27.48	38.50	82.83
RSP	180	$\mu g/m^3$	163.57	6.75	29.74	24.15	24.04	34.97	51.64
Nicotine	6.8	$\mu g/m^3$	5.26	0.95	1.438	1.15	0.95	0.95	3.95
Benzene	16.1	$\mu g/m^3$	102.09	0.32	6.57	15.24	3.03	5.98	16.99
Carbon tetrachloride	103	$\mu g/m^3$	2.05	0.63	0.78	0.30	0.63	0.79	1.26
Chloroform	163	$\mu g/m^3$	2.43	0.21	0.52	0.51	0.28	0.57	1.78
o-dichlorobenzene	500	$\mu g/m^3$	4.21	0.60	1.08	0.75	0.75	1.20	2.65
m-dichlorobenzene	500	$\mu g/m^3$	22.70	0.60	2.79	4.27	0.80	3.00	11.91
p-dichlorobenzene	200	$\mu g/m^3$	72.45	0.60	14.03	16.84	6.77	14.13	51.59
Ethylbenzene	1,447	$\mu g/m^3$	455.22	0.43	20.45	70.11	3.58	9.45	85.08
Tetrachloroethylene	250	$\mu g/m^3$	15.95	0.68	2.95	3.41	1.53	3.06	10.19
Toluene	1,092	$\mu g/m^3$	3113.70	4.05	247.76	598.51	56.72	150.98	1294.40
Trichloroethylene	770	$\mu g/m^3$	995.00	0.54	29.15	149.13	1.21	3.23	42.68
o-xylene	1,447	$\mu g/m^3$	216.77	0.87	14.91	37.30	4.55	7.37	66.87
m,p-xylene	1,447	$\mu g/m^3$	586.36	0.43	35.91	94.97	9.97	16.80	167.35
Bacteria	1,000	cfu/m^3	2777.33	38.67	739.15	541.57	598.67	959.0	1680.33
Fungi	500	cfu/m^3	1414.67	13.5	186.88	270.96	86.17	194.67	482.47

Note:

* 30-minute average

PM3006517303

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 2: Summary of Indoor Pollutant Levels Recorded from the Public Places During the Summer Survey

			Restaurant			Cinema			Shopping Mall		
Pollutant	**IAQ-O (1 hr)**	**Unit**	**High**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**	**Low**	**Mean**
CO	30,000	$\mu g/m^3$	6739.34	905.34	3344.87	3487.93	938.61	1695.87	3180.70	766.56	1659.50
CO_2	1,000[a]	ppm	1921.71	754.41	1271.63	2369.00	546.26	1362.12	1371.00	716.06	1002.60
HCHO	100[b]	$\mu g/m^3$	975.18	20.86	161.73	463.95	20.86	139.36	57.15	23.98	38.84
NO_2	200	$\mu g/m^3$	279.42	29.78	133.16	134.11	22.87	66.10	98.29	38.03	63.64
O_3	240	$\mu g/m^3$	367.25	27.48	54.36	27.48	27.48	27.48	93.32	27.48	38.46
RSP	180[a]	$\mu g/m^3$	1070.06	53.14	323.0	64.74	43.16	54.97	110.66	38.40	77.89
Nicotine	6.8[a]	$\mu g/m^3$	56.23	0.95	7.40	0.95	0.95	0.95	3.18	0.95	1.95
Benzene	16.1	$\mu g/m^3$	31.9	0.32	12.23	2.87	0.32	1.85	10.21	2.08	5.78
Carbon Tetrachloride	103	$\mu g/m^3$	1.26	0.63	0.69	2.52	0.63	1.26	0.79	0.63	0.65
Chloroform	163	$\mu g/m^3$	10.74	0.21	1.86	1.24	0.21	0.66	0.83	0.21	0.47
o-Dichlorobenzene	1,830	$\mu g/m^3$	6.61	0.60	1.26	6.61	0.60	2.04	5.56	0.60	1.69
m-Dichlorobenzene	1,830	$\mu g/m^3$	3.61	0.60	0.87	6.01	0.60	1.80	3.31	0.60	1.54
p-Dichlorobenzene	1,100	$\mu g/m^3$	37.88	1.80	11.60	42.09	1.80	12.14	36.98	1.65	13.88
Ethylbenzene	10,000	$\mu g/m^3$	29.05	0.43	7.74	11.27	1.30	3.81	20.48	1.19	8.29
Tetrachloroethylene	250	$\mu g/m^3$	31.23	0.68	5.60	5.43	0.68	1.63	7.47	0.68	1.89
Toluene	1,092	$\mu g/m^3$	451.53	4.14	104.08	8.65	6.02	7.60	232.35	9.79	85.88
Trichloroethylene	770	$\mu g/m^3$	3.23	0.54	1.02	1.08	0.54	0.65	13.85	0.54	2.74
o-xylene	4,850	$\mu g/m^3$	41.62	0.43	8.63	25.58	0.43	6.42	16.69	1.63	7.55
m,p-xylene	4,850	$\mu g/m^3$	82.37	2.6	22.85	69.37	1.73	17.86	54.09	3.25	18.75
Bacteria	1,000[a]	cfu/m^3	2275.00	125.00	1002.78	856.00	69.00	430.00	4891.00	465.33	2140.06
Fungi	500[a]	cfu/m^3	200.00	6.00	77.11	44.00	6.00	26.20	1161.00	77.00	376.54

Note:

[a] 8 hours IAQ-objective

[b] 30-minute average

PM30065173O4

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 3: Summary of Responsibilities of Government Departments Relevant to IAQ

Department	Legislation	Relevance to IAQ
Buildings Department	Buildings Ordinance Cap. 123	Requirement for mechanically ventilated premises to provide 5 air changes per hour.
Provisional Urban/Provisional Regional Council (PUC/PRC)	Public Health & Municipal Services Ordinance, Cap. 132	Dampers, filters & precipitators are inspected yearly by registered ventilation contractor. Specified ventilation rates for scheduled premises.
	Places of Public Entertainment Regulations, Cap. 172	Requires provision of sufficient ventilation to the public places. A fresh air supply requirement of $13m^3/h$/person is imposed on all entertainment machine centres.
Labour Department	Factories & Industrial Undertakings Ordinance, Cap. 59	Requirements to protect workers (workplace safety and measures of work practice as well as medical surveillance).
	Occupational Safety & Health Ordinance, Cap. 509	Requires the provision of safe and healthy workplace for office workers in addition to industrial workers. Provision of adequate ventilation & air within workplace should be kept free of impurities.
Health Department, Commission of Police, PUC/PRC, TV & Licensing Authority	Smoking (Public Health) (Amendment) Ordinance, Cap. 371; Code of Practice under Broadcasting Authority Ordinance	Control measures relating to prohibition of advertisements, designated 'No Smoking' areas, 'No Smoking' signs, etc.
Customs & Excise Department	Consumer Goods Safety Ordinance, Cap. 456 Ozone Layer Protection Ordinance, Cap. 403 Air Pollution Control Ordinance, Cap. 311	Control of import of consumer goods with focus on product safety and enforcement of import control on ozone-depleting substances & asbestos through import licensing (as authorised by EPD).
Agriculture & Fisheries Department	Pesticides Ordinance, Cap. 133	Control of import, manufacture, supply & sale (but no control of use of registered pesticides).
Environmental Protection Department	Air Pollution Control (Amendment) Ordinance, Cap. 311	Established Air Control Zones and the associated Air Quality Objectives Control of asbestos in environment.

PM3006517305

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Abbreviations

AC	-	Air Conditioning
ACGIH	-	American Conference of Governmental Industrial Hygienists, U.S.
ACM	-	Asbestos-Containing Materials
AFD	-	Agriculture and Fisheries Department
AHU	-	Air Handling Unit
AIHA	-	American Industrial Hygiene Association, U.S.
ANSI	-	American National Standards Institution, U.S.
APCO	-	Air Pollution Control Ordinance (CAP 311)
ARB	-	Air Resources Board, U.S.
ASHRAE	-	American Society of Heating, Refrigerating and Air-conditioning Engineers
B(VS)R	-	Building (Ventilation Systems) Regulations
BA	-	Building Authority
BASE	-	Building Assessment Survey and Evaluation
BHSW	-	Board of Health and Social Welfare
BOMA	-	Building Owners and Managers Association
BRE	-	Building Research Establishment
BREEAM	-	Building Research Establishment Environmental Assessment Method
BRI	-	Building-Related Illness
BSI	-	Building Symptom Index
Cal/OSHA	-	California, Division of Occupational Safety and Health Administration, U.S.
CAPCOA	-	California Air Pollution Control Officers Association, U.S.
CATIS	-	Computer Assisted Telephone Interviewing System
CAV	-	Constant Air Volume
CEC	-	California Energy Resources Conservation and Development Commission, U.S.
CI	-	Confidence Interval
CIAQS	-	California Indoor Air Quality Section, U.S.
CIBSE	-	Chartered Institution of Building Service Engineers, U.K.
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
COHb	-	Carboxyhaemoglobin
CoP	-	Code of Practice
COSHH	-	Control of Substances Hazardous to Health, U.K.
DG	-	Dangerous Goods
DoE	-	Department of the Environment, U.K.
EEAC	-	The Energy Efficiency Advisory Committee
EHOs	-	Environmental Health Offices
EIA	-	Environmental Impact Assessment
EMSD	-	Electrical and Mechanical Services Department, Hong Kong Government
EPA	-	Environmental Protection Agency, U.S. (US EPA)
EPD	-	Environmental Protection Department, Hong Kong Government
ETS	-	Environmental Tobacco Smoke
EU	-	European Union
F&IU	-	Factories and Industrial Undertakings
HCHO	-	Formaldehyde
HEPA	-	High Efficiency Particulate Air
HETAB	-	The Health Hazard Technical Assistance Branch
HKAQO	-	Hong Kong Air Quality Objective
HKBEAM	-	Hong Kong Building Environmental Assessment Method
HSE	-	Health and Safety Executive, U.K.
HVAC	-	Heating, Ventilation, and Air Conditioning
IAQ	-	Indoor Air Quality
IAQ-Sim	-	Indoor Air Quality Simulator
IAQ-O	-	IAQ Objective
IAQMG	-	IAQ Management Group
IAQP	-	IAQ Perception
IARC	-	International Agency for Research on Cancer
ICOH	-	International Commission of Occupational Health
IFMA	-	International Facility Management Association
IWSB	-	Industry Wide Studies Branch
LBL	-	Lawrence Berkeley Laboratory, U.S.
LCP	-	Life-time Cancer Probability
LD	-	Labour Department, Hong Kong Government

PM3006517306

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

LED	-	Legionnaires' Disease
MEA	-	Malt Extract Agar
MELs	-	Maximum Exposure Limits
MSR	-	Minimum Supply Rate
MTR	-	Mass Transit Railway
MVAC	-	Mechanical, Ventilation, and Air Conditioning
NBHBP	-	National Board of Housing, Buildings and Planning, U.S.
NDIR	-	Non-Dispersive Infra-Red
NHMRC	-	National Health and Medical Research Council, U.S.
NIOSH	-	National Institute for Occupational Safety and Health, U.S.
NIST	-	National Institute of Standards and Technology, U.S.
NO_2	-	Nitrogen Dioxide
NT	-	Non-Threshold
O_3	-	Ozone
OEHHA	-	Office of Environmental Health Hazard Assessment
OELs	-	Occupational Exposure Limits
OESs	-	Occupational Exposure Standards
OS	-	On-Site
OS&H	-	Occupational Safety and Health
OS&H Bill	-	Occupational Safety & Health Bill
OSHA	-	Occupational Safety and Health Administration
PCA	-	Plate Count Agar
QC	-	Quality Control
RELs	-	Reference Exposure Levels
RH	-	Relative Humidity
RSP	-	Respirable Suspended Particulates
SBS	-	Sick Building Syndrome
SF_6	-	Sulphur hexafluoride
SISIR	-	Singapore Institute of Standards and Industrial Research
SOPs	-	Standard Operating Procedures
SQL	-	Sequential Query Language
SSRC	-	Social Science Research Centre, the University of Hong Kong
STEL	-	Short-Term Exposure Level
TH	-	Threshold
TLV	-	Threshold Limit Value, ACGIH
TS	-	Telephone Survey
TVOC	-	Total Volatile Organic Compounds
TWA	-	Time-Weighted Average
UC/RC	-	Urban/Rural Council
URF	-	Unit Risk Factor
USD	-	Urban Services Department
UV	-	Ultra Violet
VAV	-	Variable Air Volume
VDU	-	Video Display Unit
VOCs	-	Volatile Organic Compounds
WHO	-	World Health Organisation

PM3006517307

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

TABLE OF CONTENTS

		Pages
	Acknowledgement	
	Executive Summary	1 - 7
	Abbreviation	i - ii
	Table of Contents	i - iv
	Contents	*i - iii*
	List of Tables	*iv*
	List of Figures	*iv*
	CONTENT	
1.	**INTRODUCTION**	**1-1**
1.1	Background	1-1
1.2	Objective of the Study	1-2
1.3	Scope of Work	1-2
1.3.1	Information collation	1-2
1.3.2	Study of overseas practice	1-2
1.3.3	Detailed study of offices	1-2
1.3.4	Pilot study of Public Places	1-3
1.3.5	Design and production of computer assisted tools / models	1-3
1.3.6	Recommendations for action	1-3
1.4	Structure of the study team	1-3
1.5	Consultancy management	1-4
1.6	Submissions of working reports	1-5
1.7	Other discussion and forum	1-5
1.8	Structure of reporting	1-5
2.	**PREPARATION AND PLANNING FOR THE STUDY**	**2-1**
2.1	Introduction	2-1
2.2	Office building stock	2-1
2.3	Identification of office premises for on site IAQ monitoring	2-2
2.4	The selected sample distribution	2-4
2.5	Types of public places selected for IAQ monitoring	2-4
2.6	Factors affecting IAQ	2-6
2.7	Sources of indoor air contaminants and their health effects	2-8
2.8	On-site survey parameters	2-12
2.9	Design of questionnaire survey	2-13
2.10	Conclusion	2-14
3.	**QUESTIONNAIRE SURVEY**	**3-1**
3.1	Introduction	3-1
3.2	Telephone survey	3-1
3.3	On-site questionnaire survey	3-1
3.4	Criteria for random selection of respondents	3-2
3.5	Questionnaire design	3-2

PM3006517308

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

3.6	Quality control on telephone survey		3-3
3.7	Confidentiality of the on-site questionnaire survey		3-3
3.8	Results of both questionnaire surveys		3-3
	3.8.1	Personnel information	3-3
	3.8.2	Perception on indoor air quality	3-4
	3.8.3	Odour source	3-4
	3.8.4	Dust problem	3-4
	3.8.5	Temperature, relative humidity and draught	3-5
	3.8.6	Smoking habit	3-5
	3.8.7	Medical history	3-5
	3.8.8	Type of ventilation during overtime work	3-5
	3.8.9	Air-cleaning device	3-5
	3.8.10	Openable windows	3-6
	3.8.11	Office decoration / water damage	3-6
	3.8.12	Office equipment	3-6
	3.8.13	Office stationery	3-6
	3.8.14	Sick building syndrome symptoms	3-6
	3.8.15	Cold / flu and sickness	3-7
	3.8.16	Perception on IAQ in public places	3-7
	3.8.17	Building Symptom Index	3-7
3.9	Conclusion		3-8
4.	**ON-SITE SURVEY**		**4-1**
4.1	Introduction		4-1
4.2	Office premises survey		4-1
4.3	Public places surveyed		4-1
	4.3.1	Restaurants	4-1
	4.3.2	Cinema	4-1
	4.3.3	Shopping mall	4-1
	4.3.4	Wet market	4-2
	4.3.5	Mass Transit Railway	4-2
	4.3.6	Train compartment	4-2
4.4	Selection of the monitoring method		4-2
4.5	The survey team		4-3
4.6	Arrangement with the building proprietors		4-3
4.7	Measurement strategy		4-3
4.8	The survey protocol		4-3
4.9	Results of the office surveys		4-8
4.10	Results of the longitudinal study		4-17
4.11	Results of the public place surveys		4-23
4.12	Results of the Mass Transit Railway (MTR) surveys		4-35
4.13	Conclusion		4-38
5.	**ANALYTICAL STATISTICS**		**5-1**
5.1	Introduction		5-1
5.2	Methodology		5-1
5.3	Results		5-2

PM3006517309

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

5.4	Projection of percentage of sick building	5-4
5.5	Regression analysis	5-5
5.6	Radon analysis for residential sector	5-7
5.7	Conclusion	5-8
6.	**REVIEW OF PRACTICE IN SELECTED COUNTRIES**	**6-1**
6.1	Introduction	6-1
6.2	Australia	6-1
6.3	Canada	6-3
6.4	Japan	6-5
6.5	South Korea	6-6
6.6	Singapore	6-8
6.7	Sweden	6-9
6.8	United Kingdom	6-10
6.9	United States	6-12
6.10	Hong Kong	6-15
6.11	Conclusion	6-23
7.	**PRODUCTS / TOOLS OF THE CONSULTANCY**	**7-1**
7.1	Introduction	7-1
7.2	Database	7-1
7.3	Human exposure assessment model	7-2
7.4	Technical mitigation measures	7-7
7.5	Code of Practice	7-8
7.6	Conclusion	7-10
8.	**DISCUSSION ON RESULTS AND CONTROL STRATEGY ON INDOOR AIR QUALITY**	**8-1**
8.1	Introduction	8-1
8.2	Current IAQ situation of offices	8-1
8.3	Current IAQ situation of public places	8-2
8.4	The justification for control measures to be established	8-2
8.5	Economic impact related to indoor air quality	8-3
8.6	Evaluation of options available for control schemes	8-4
8.7	Options for Hong Kong	8-6
8.8	The Way Forward	8-10
8.8.1	Setting up of an IAQ Management Group	8-10
8.8.2	IAQ programme assessment	8-11
9.	**OVERALL CONCLUSION AND RECOMMENDATION**	**9-1**

PM3006517310

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

LIST OF TABLES

		Pages
2-1	Number of existing stock of private office building	2-1
2-2	Regional distribution of the stock of private office space as at 1995	2-1
2-3	Regional distribution of the stock of private office building as at 1995	2-2
2-4	Regional distribution of the stock of Government owned offices as at 1995	2-2
2-5	Target distribution of sampling premises according to data on building stock	2-2
2-6	Distribution of the sampling premises according to actual on-site survey	2-4
2-7	Distribution of the public places surveyed (unit surveyed by location)	2-5
3-1	Response of the 6 building sickness symptoms from the questionnaire surveys	3-7
4-1	Equipment / methods adopted in the survey	4-4
4-2	Average indoor air pollutant levels at MTR platforms and concourses	4-35
4-3	Average indoor air pollutant level at MTR train compartment	4-37
5-1	Parameters specifically targeted at to identify correlation	5-2
6-1	Summary of responsibility of government department relating to indoor air pollution	6-18
6-2	Proposed interim indoor air quality guideline	6-19
6-3	IAQ related legislation and codes adopted in eight countries studied	6-24
6-4	Summary on IAQ standards / guidelines (maximum levels)	6-28
6-5	Summary on Ventilation Standards/Guidelines	6-29
7-1	Recommended indoor air quality objectives for Hong Kong	7-11
7-2	Indoor air quality objectives for individual VOCs	7-12
8-1	Evaluation of the different approaches to achieve IAQ objectives from the administrative perspective	8-7
8-2	Summary of responsibilities of government department relevant to IAQ	8-12

LIST OF FIGURES

		Pages
1-1	Study team	1-4
4-1	Level of Fresh Air Flow Rate and ASHRAE 62-1989R Requirement	4-8
4-2	Level of CO_2	4-10
4-3	Level of HCHO	4-11
4-4	Level of ozone	4-12
4-5	Level of fungi	4-15
4-6	Level of bacteria	4-16
4-7	Level of carbon dioxide in public places	4-25
4-8	Level of NO_2 in public places	4-26
4-9	Level of RSP in public places	4-27
4-10	Level of ozone in public places	4-28
4-11	Level of HCHO in public places	4-29
4-12	Level of nicotine in public places	4-30
4-13	Level of fungi in public places	4-33
4-14	Level of bacteria in public places	4-34
7-1	Structure diagramme of the database system	7-2

PM3006517311

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

TABLE OF CONTENTS

APPENDICES

Appendix I	:	Programme of Seminar on Indoor Air Quality
Appendix II	:	ASHRAE Standard (62-1989R) as the Proposed New Minimum Air Supply Rate (MSR)
Appendix III	:	Details on Factors Affecting Indoor Air Quality: Physical Factors and Emission Sources
Appendix IV	:	Questionnaire for Telephone and On-site Survey
Appendix V	:	Results of the Telephone Survey and On-site Questionnaire Survey
Appendix VI	:	Protocol and Results of On-site Survey - Offices Premises
Appendix VII	:	Protocol and Results of On-site Survey - Public Places
Appendix VIIIa	:	Correlation from Computer Printouts
Appendix VIIIb	:	Correlation from Computer Printouts (revised Building Symptoms index (BSI) on skin allergy)
Appendix IX	:	Example of SQL Database
Appendix X	:	Human Exposure Index: Values for Calculations
Appendix XI	:	An Example of How to Run IAQSim V1.0
Appendix XII	:	Significant Percentile of Indoor Air Pollutants
Appendix XIII	:	Cost Estimates for IAQ Improvement ; and, Organisational Structure of IAQ Management Group

PM3006517312

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

1. INTRODUCTION

1.1 Background

1.1.1 EHS Consultants was commissioned by the Environmental Protection Department of the Hong Kong Government in October 1995 to undertake the "Consultancy Study on Indoor Air Pollution in Offices and Public Places in Hong Kong, Agreement No. CE 14/95" for a period of eighteen months.

1.1.2 Indoor air quality (IAQ) has become an important element in modern life as most people spend more than 70% of their times indoors. In the developed world, concerns on Sick Building Syndrome describing a collection of health symptoms which cannot be specifically identified medically, have prompted numerous research and extensive government initiative to find out and mitigate the problems.

1.1.3 There are several reasons which have aggravated the indoor air problem in the post-war era. One of the reasons can be attributed to the increasing demand for indoor spaces in conjunction with the decreasing supply of traditional building material giving rise to the use of new synthetic building materials. New mineral composites were also used for their fire-retarding characteristics. However, not much consideration was given to the health effect of fugitive chemical emissions and respirable particulates associated with these new, non-traditional building materials until long after these materials were in use.

1.1.4 As a consequence of the energy crisis in the early 1970s, buildings were "sealed" for the purpose of energy conservation. New heating, ventilation, and air conditioning (HVAC) systems were designed and installed with much less outdoor air makeup. Synthetic technology was applied to meet the insulation requirement changes. As a result, modern buildings are much "tighter" and there is less infiltration of outdoor air and exfiltration of indoor air.

1.1.5 New technologies, including photocopying machine, computer workstations, electro-photographic colour reproduction equipment, and high-end printers producing hundreds of pages per minute, were massively introduced into offices following the technology boom. When installed without adequate ventilation, these equipment and machines can promote indoor air quality problems.

1.1.6 Technical advances enabling the detection of ever lower levels of chemical and biological agents have a dramatic impact upon indoor air quality. Medical research has demonstrated that there are correlations between chronic health problems and long-term exposure even down to very low levels of indoor air pollutants [1,2].

1.1.7 A World Health Organisation (WHO) study[3] has estimated that up to 30% of modern commercial buildings may suffer from sub-standard indoor environments due to a variety of reasons. The poor quality of indoor air has led to a reduction in productivity as people at work suffer from sub-optimal health. Even though indoor air quality may not be considered to directly cause debilitating diseases, its impacts on general well-being and economic loss certainly justify efforts to identify the problems and appropriate actions to ameliorate the effects[4].

1.1.8 In Hong Kong the Government recognised the importance of the issue of indoor air quality in "the Second Review of the 1989 White Paper on Pollution in Hong Kong, 1993"[5] and resolved that the potential health risk and other associated problems due to indoor air pollution need to be addressed. As a result, the present study was launched.

1.1.9 Prior to this, a pilot study on the indoor air quality of 35 shops and 35 offices in Hong Kong conducted in 1990 found that over 30% suffered from excessive levels of carbon dioxide

PM3006517313
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

while many suffered from different degrees of exposure for formaldehyde, environmental tobacco smoke, volatile organic compounds and microbes[6].

1.1.10 Since ventilation is closely related to indoor air quality, numerous researchers have carried out studies in this area in the academic institutions and identified problems with ventilation systems, formaldehyde levels, and microbial growths[7,8].

1.1.11 With the increasing pressure from the public in Hong Kong demanding an improved quality of life, indoor air quality has inevitably come into focus. It is therefore timely for this study to take place; the outcome of which will set the stage for future strategy on this very important subject.

1.2 Objective of the Study

1.2.1 The main objective of the study is to characterise and quantify the indoor air pollution in office premises and selected public places in Hong Kong. For offices, more extensive information was obtained to study the correlation of the perception of people on their indoor air quality with significant indoor air quality indicators enabling the identification of problem causing parameters hence better understanding of the "Sick Building Syndrome". For public places, the specific problems were identified by a pilot study.

1.2.2 With the problems identified, the study is also designed to propose strategies and procedures to mitigate the problems. The target is to formulate indoor air objectives and codes on indoor air quality management based on internationally acceptable standards which are attainable and feasible in the short and medium terms. The Consultant will also propose a system to institutionalise the control of indoor air quality which can be integrated with current legislative and administrative system and is achievable under a reasonable time frame laying the foundation for a long term policy on the indoor air quality issue.

1.3 Scope of Work

1.3.1 Information collation

The study includes an extensive literature search into statistical data on office buildings covering the categorisation, distribution, physical parameters and occupancy levels. It also covers information from international publications on factors affecting indoor air quality and sources and types of indoor pollutants with particular emphasis on those applicable to Hong Kong. Sampling protocols and testing techniques were explored with the purpose of establishing the most suitable methods for Hong Kong and to be used in this study.

1.3.2 Study of overseas practice

Detailed study of the current situation on indoor air quality in eight developed countries was performed, the countries include Australia, Canada, Japan, Korea, Singapore, Sweden, United Kingdom and the United States. The information targeted at were indoor air quality studies in progress, as well as control measures/ legislation in place.

1.3.3 Detailed study of offices

The project covers a detailed study of selected sample offices which constitute a representative sample of the entire population of offices in Hong Kong. The approach was two-pronged : through an initial telephone survey of 2,000 office workers and on-site survey from this pool, 40 commercial buildings with 25 or more occupants were randomly selected for detailed monitoring according to the overall sample distribution characteristics for Hong Kong. With detailed correlation and regression analysis, the problems and their causes were identified.

PM3006517314
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

1.3.4 Pilot study of Public Places

A selection of 20 restaurants, 5 cinemas, 8 shopping centres, 2 wet markets and the Mass Transit Railway (train, platform and concourse) was surveyed. The data obtained were analysed to give an indication of the indoor air quality at these premises.

1.3.5 Design and Production of Computer assisted tools / models

The study produces a comprehensive SQL database on all the data collected with user-friendly manipulations to produce descriptive statistic. The database can be expanded to accommodate future addition.

The study also produces a human exposure model on indoor air quality. The model is to provide a tool for simulation of indoor air quality levels using known building physical parameters, coupled with a risk assessment model to provide an exposure index.

1.3.6 Recommendations for action

By taking into account results of the survey, monitoring, local and overseas practice, cost effective mitigation measures are recommended. The measures include engineering technical mitigation measures, management controls or even legislative compulsion. An overall strategy for short term and long term is provided after initial consultation with relevant bodies. A Code of Practice for the Management of Indoor Air Quality was produced as an overall guideline used in self-regulation.

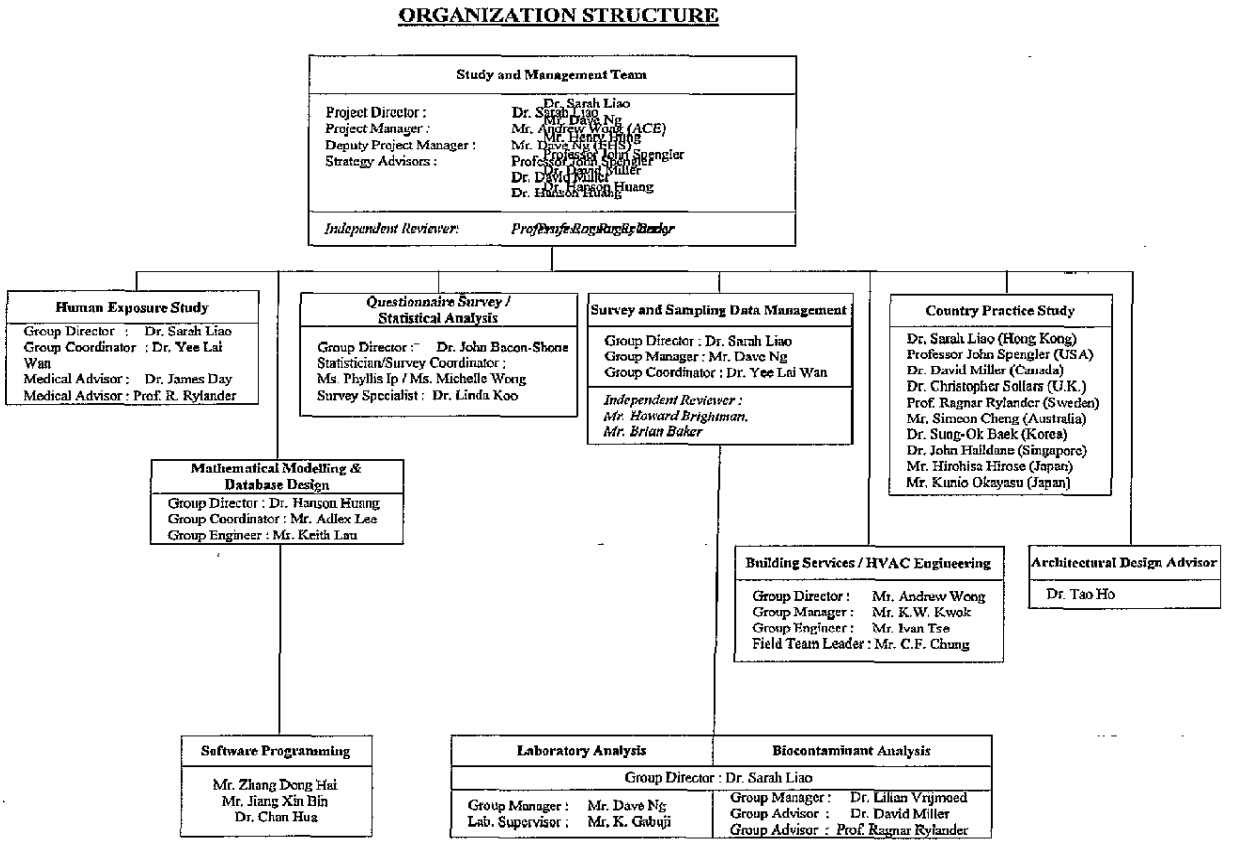
1.4 Structure of the Study Team

1.4.1 EHS Consultants Ltd leads a team of local and overseas consultants to conduct the study (see Figure 1-1).

PM3006517315

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Figure 1-1 Study Team



1.5 Consultancy Management

1.5.1 A Steering Committee was set up consisting of the following membership :-

(i) Secretary for Planning, Environment & Lands

(ii) Architectural Services Department

(iii) Electrical & Mechanical Services Department

(iv) Environmental Protection Department

(v) Department of Health

(vi) Labour Department

The terms of reference are:-

(i) To provide advice and guidance to the Consultants in assisting them to achieve the objectives of the study.

(ii) To consider progress reports and monitor the overall progress of the study

(iii) To provide a forum for discussing major issues among government departments and to convey government's decisions and views to the Consultants.

(iv) To consider and agree, if appropriate, working papers/reports submitted by the Consultants.

(v) To consider the study output and the Consultants' recommendations.

PM3006517316
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

The Steering Group met for nine times during the course of the Study on the following dates:-

(i) December 4, 1995
(ii) January 18, 1996
(iii) April 16, 1996
(iv) June 3, 1996
(v) August 6, 1996
(vi) October 9, 1996
(vii) December 5, 1996
(viii) March 4, 1997
(ix) April 9, 1997

1.6 Submissions of Working Reports

1.6.1 In the course of the study, the reports submitted include:-

- Inception Report
- Milestone Reports for Study Tasks 1 to 13
- Bimonthly Progress Reports 1-10
- Data analysis report on Radon

1.6.2 The Consultant also submitted the following computer software products:-

- Microsoft Access® Database on survey data
- Indoor Air Quality Simulator (IAQ-Sim) software on simulation of Human Exposure
- Sequential Query Language (SQL) database - relational SQL database on Windows-NT® Platform
- Radon model - Windows platform prediction model

1.7 Other Discussions and Forum

A seminar on indoor air quality was organised on January 19, 1996 with key personnel from government departments and local and overseas experts presenting their views and research findings at a public seminar. Altogether 48 participants of management level from 32 organisations of the private sector attended the seminar. A second seminar was held for Government departments, academics and legislators with a total of 40 participants. The details of the programme are contained in Appendix I.

Throughout the 18 months, over 45 working meetings were held with representatives from Environmental Protection Department to ensure good co-ordination and expedient response to issues. In addition, at least 12 sessions of discussions were held will relevant departments and organisations to seek their views on indoor air quality as well as to explore possibilities of including indoor air quality management in their existing system.

1.8 Structure of Reporting

In addition to this Introduction Chapter which gives the background, objective and management structure of the study, the reports consists of the following chapters:-

Chapter 2: **Preparation and Planning for the Study**

PM3006517317
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

describes how offices buildings and public places were selected to give representative samples; researches into the factors which may influence indoor air quality and the possible emission sources and their impact on the occupants - all information is then used to design the questionnaire and on-site survey protocol.

Chapter 3: **Questionnaire Survey**

describes the survey methodology of the telephone and on-site survey, presents summary of results and comments on the population selected and the comparability of the responses from both questionnaires

Chapter 4: **On-Site Survey**

presents a summary of the protocol on the detailed sampling and survey on-site, with results on office, restaurant, cinema, shopping arcade, wet market and the MTR surveys with comments on the samples which exceed guidelines.

Chapter 5: **Analytical Statistics**

describes the statistical methods used to analyse the data collected with specific targets to identify correlation between perceptive parameters and measured levels as well as with actual health symptoms; presents regression models for prediction of indoor air quality and projection analysis of sick buildings in Hong Kong.

Chapter 6: **Review of Practice in Selected Countries**

summarises situations on indoor air quality issues for eight countries plus Hong Kong with regard to legislation, standard and guidelines, efforts on indoor air quality study and general strategic and policy direction.

Chapter 7: **Products/Tools of the Consultancy**

presents the tools and means to allow prediction of indoor air quality and control of indoor air quality in general, includes database, human exposure model IAQ-Sim 1.0, technical mitigation measures and code of practice.

Chapter 8: **Discussions on Results and Control Strategy on Indoor Air Quality**

presents arguments for and against various models for control based on experience of advanced countries and Hong Kong situations, points out areas which are sub-standard and the economic impact of poor indoor air quality on productivity, goes into depth on the four possible options.

Chapter 9: **Overall Conclusion and Recommendation**

summarises conclusions by categories: technical measures, management systems, policy and strategy.

PM3006517318

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

1 Samet J., Marbury M., and Spengler J., (1987). Health Effects and Sources of Indoor Air Pollution. Part I, *Am. Rev. Respir. Dis.* 136: 1486-1508.

2 Samet J., Marbury M., and Spengler J., (1988), Health Effects and Sources of Indoor Air Pollution. Part II, *Am. Rev. Respir. Dis.* 137: 1486-1508.

3 WHO, (1983), Indoor Air Pollutants : Exposure and Health Effects, EURO Reports and Studies 78, Copenhagen : World Health Organisation.

4 Stenberg, B. et al. (1990)The Office Illness Project in Northern Sweden. Part I: A Prevalence Study of Sick Building Syndrome (SBS) Related to Demographic Data, Work Characteristics and Building Factors, In *Proceedings of the Fifth International Conference of Air Quality and Climate*, Vol.4, pp. 627-32.

5 Secretary for Planning, Environment and Lands, Environment Branch, 2nd Review of 1989 While Paper. A Time to Act. Hong Kong Government Printers.

6 Liao S., Bacon-Shone J., and Kim Y.S., (1991), "Factors Influencing Indoor Air Quality in Hong Kong : Measurements in Offices & Shops", *Environmental Technology*, Vol.12, pp. 737-49.

7 Leung R., and Poon H., (1993), Overview of Indoor Air Pollution. Paper presented in Seminar on Sick Building Syndrome, Legal Business in Asia, 15 Nov., 1993, Hong Kong. p.3.

8 Au YeungY.N., Chow, W.K., and Lam V.Y.K., (1990), Sick Building Syndrome - A Case Study, Department of Building Services Engineering, Hong Kong Polytechnic, Hong Kong, p.3.

PM3006517319

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

2. PREPARATION AND PLANNING FOR THE STUDY

2.1 Introduction

2.1.1 This chapter explains how the 40 samples of offices for detailed survey were selected and how they were linked to the questionnaire survey to allow for future projection of the data collected to the entire population.

2.1.2 The parameters considered in the questionnaire surveys as well as the detailed monitoring were research into such that the factors which affect IAQ and the sources of emissions were identified and included in the study protocols.

2.2 Office Building Stock

2.2.1 The purpose of the selection is to cover all the categories of office buildings (A, B and C) with central air conditioning (by the different types) at different districts in Hong Kong. The matrix selected was matched against those obtained from the telephone survey eventually to create the link whenever possible. Based on the data supplied by the Rating and Valuation Department, the existing stock of office buildings is estimated to be about 1,453 (see Table 2-1).

2.2.2 Office buildings in Hong Kong are made up of private offices and government owned offices. They are generally sub-divided into office classes A, B and C according to: i) the external appearance and finishes, ii) the state of the lobby, iii) lift facility, and iv) the services provided by the building management. The higher the grade, the more advanced the air conditioning system.

Table 2-1 Number of Existing Stock of Private Office Buildings

Year	No. of office space (by floor area)	No. of commercial buildings (referring to the stock of office space)
1980	2.4 million m^2	830
1990	5.1 million m^2	1,340
1995	7.2 million m^2	1,453*

Note (*): Unpublished, supplied by request from Rating and Valuation Department, 1997
Source: TDSR, Department of Planning, 1990; Rating and Valuation Department, 1995

2.2.3 An overall distribution pattern of the stock of private office space by regional distribution and office class is shown in Table 2-2:

Table 2-2 Regional Distribution of the Stock of Private Office Space as at 1995

Distribution of office space	m^2 (in million)	%	Class A (in %)	Class B (in %)	Class C (in %)
Hong Kong Island	4.71	65.46	64.95	68.00	63.68
Kowloon	1.78	24.78	21.98	26.67	31.06
New Kowloon	0.40	5.51	7.56	2.29	3.37
New Territories	0.30	4.25	5.15	3.04	1.90
TOTAL	7.19	100.00	100.00	100.00	100.00

2.2.4 Table 2-3 shows that a large proportion of the stock of office space was class A in 1995 and over 65% of the overall stock was located on Hong Kong Island.

PM3006517320
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 2-3 Regional Distribution of the Stock of Private Office Buildings as at 1995

Distribution of office building	No. of unit of buildings	%	No. of unit Class A		No. of unit Class B		No. of unit Class C		Total (no. of unit of bldg)
Hong Kong Island	174	65.46	102	59.0%	202	62.0%	666	70.0%	970
Kowloon	326	24.78	51	29.0%	107	32.8%	243	25.5%	401
New Kowloon	638	5.51	11	6.3%	8	2.5%	33	3.4%	52
New Territories	315	4.25	10	5.7%	9	2.7%	11	1.1%	30
TOTAL	1,453	100%	174	100%	326	100%	953	100%	1,453

2.2.5 A comparison between Table 2-2 and Table 2-3 reveals that there is more floor area in office class A than the other classes. The larger number of Class C buildings is in part due to the demand in the mid 1970s. The government then permitted a higher plot ratio for buildings and many of such non domestic buildings were allowed for use as offices (i.e., issued occupation certificate as office). Hence, the large number of buildings in class C noted from Table 2-3.

2.2.6 Government buildings and those belonging to public utilities have also been included in the sample selection. The stock of government owned buildings is shown in Table 2-4.

Table 2-4 Regional Distribution of the Stock of Government Owned Offices as at 1995

Distribution of Government owned office space	m^2	%	Class A (in %)	Class B (in %)	Class C (in %)
Hong Kong Island	417,510	60.52	91.85	27.46	21.39
Kowloon	128,181	18.58	8.15	31.13	25.53
New Kowloon	55,338	8.02	0	9.44	45.86
New Territories	88,817	12.88	0	31.97	7.22
TOTAL	689,845	100.00	100.00	100.00	100.00

2.3 Identification of Office Premises for On-Site IAQ Monitoring

2.3.1 The major building characteristics to take into account in the selection of office premises for IAQ monitoring are: office class or ranking of the building, location by district and type of artificial ventilating systems installed.

2.3.2 Ideally, the target number of samples (i.e., 40) is set according to their frequency distribution by the 18 districts as shown by the matrix (see Table 2-5). The data by floor area are reported in Milestone Report, Study Task 1.

Table 2-5 Target Distribution of the Sampling Premises According to Data on Building Stock

Location of Offices	Class A	Class B	Class C
West, Sheung Wan, Central	8	3	3
Admiralty, Wan Chai, Causeway Bay	4	3	1
East, North Point, Quarry Bay	2	1	
Hong Kong Island : *Sub-Total*		*25*	
Tsim Sha Tsui, Yau Ma Tei, Mong Kok	4	1	2
West Kowloon	2		
East Kowloon	2		
Kowloon : *Sub-Total*		*11*	
Tsuen Wan	2		
Northern New Territories	2		

PM3006517321

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

New Territories : *Sub-Total*	4

2.3.3 An observation made is that about two-third of the private offices were located on Hong Kong Island and another one-quarter in Kowloon. The core office districts are Sheung Wan, Central, Wan Chai, Causeway Bay and Tsim Sha Tsui. In the context of this IAQ study, distribution by geographical location is important only so far as the outdoor environment is concerned. Some of the districts have been grouped in order to have enough samples within the cell. As such, only eight broad groups were used. In the sample selection, government buildings have been included.

2.3.4 The samples within each of the 8 districts are further stratified by the mechanical ventilating systems installed. This is made possible by the database collected from the telephone questionnaire survey where complete information on building identity was provided by the respondents. From the random selection of a total of 2,000 samples in the telephone survey of office workers, there was a small proportion who were less prepared to disclose the names of their office buildings. The base from which samples could be randomly selected was around 800 buildings. Information on the air-conditioning system was searched for through different sources.

2.3.5 Only central air-conditioned and mechanical ventilated commercial buildings were selected as they were by far the commonest type. Members of the Private Sector Committee on the Environment are also invited to participate in the Study. In terms of the air conditioning systems presently installed in Hong Kong, the common ones are:

2.3.6 Fan Coil Unit (FCU) system with pre-treated fresh air supply to the air conditioned area.

2.3.7 Constant Air Volume (CAV) system by larger air handling plant for medium and low class office building.

2.3.8 Variable Air Volume (VAV) system for interior zone with CAV for external zone to provide cooling and heating in summer and winter respectively. Fresh air supply is variable in proportion with the variable supply air quantity.

2.3.9 VAV system with terminal heating. Fresh air supply is variable in proportion with the variable supply air quantity.

2.3.10 Buildings which satisfy all three key parameters, i.e., building class, location by district and air-conditioning systems were pre-qualified and each has equal chance to be selected for sampling. Consequently, the population of those premises where the information provided is complete was further reduced.

2.4 The Selected Sample Distribution

2.4.1 In practice, a total of thirty-four existing office buildings were identified for the survey while the remaining six buildings were government owned buildings or premises belonging to public utilities.

2.4.2 The final selection of the samples was based on the willingness of the proprietors or building owners to volunteer to participate in the IAQ study. The co-operation of the building owners was sought. The willing participants tend to be those who were more certain of their indoor air quality would be more likely to participate in the study, or those who suspected that their premises might have slight IAQ problems were prepared to collaborate in the study.

2.4.3 Table 2-6 shows the distribution of the surveyed samples.

PM3006517322

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 2-6 Distribution of the Sampling Premises According to Actual On-site Survey

Location of Offices	Class A	Class B	Class C
West, Sheung Wan, Central	8	4	
Admiralty, Wan Chai, Causeway Bay	4	3	1
East, North Point, Quarry Bay	3		
Hong Kong Island : *Sub-Total*		*23*	
Tsim Sha Tsui, Yau Ma Tei, Mong Kok	5	2	
West Kowloon	1		
East Kowloon	1		
Kowloon : *Sub-Total*		*9*	
Tsuen Wan	1	1	
Northern New Territories			
New Territories : *Sub-Total*		*2*	

2.5 Types of Public Places Selected for IAQ Monitoring

2.5.1 The indoor air quality of selected public places were considered in a pilot study which is part of the present consultancy. The Steering Group recognised the importance of the indoor environment of public places even though people may spend less time there generally. The public places identified for IAQ study were:

Selected Public Places	No. of Units Monitored
Shopping mall / department store	8
Cinemas	5
Restaurants	20
Wet market	2
MTR	concourse, platform and train compartments

2.5.2 Out of the eight shopping malls/ department stores selected for the study, two were selected from commercial centres owned and managed by the Housing Department which houses 3 million of Hong Kong's population. As for the remaining six, they were owned and managed by the private sector and located throughout the various districts in Hong Kong. One of them was a large departmental store. Some of the samples covered are located within the metropolitan area while others are in the new town development areas.

2.5.3 A total of five cinemas were studied. They vary in sizes and age and they are located in the different districts. However, two particular cinemas were identified by the respondents in the IAQ telephone questionnaire survey as having poor air quality. Thus, they were included for the sampling.

2.5.4 Similarly, two of the twenty restaurants in the IAQ study were those in which respondents from the IAQ telephone questionnaire survey identified as having poor air quality. In terms of sample selection, the study took into account factors which are likely to affect indoor air quality. For this purpose, numerous types of restaurants were covered. They include all the varieties of cooking, including the Korean barbecue, hot pot and teppanyaki restaurants throughout major urban districts. Dim sum lunch at Chinese restaurant constituted 5 of the 20 surveys as it was considered a most common way of lunch for the Hong Kong people. Other more common types of lunch included a variety of fast food shops such as pizza, and hamburger. For dinner, two Korean, one Chinese hot pot, and one Mongolian restaurants were chosen as they are considered as a special group with a direct source of combustion in the dining area. Other restaurants studied included Western buffet, steak house, Indian/ Thai

PM3006517323

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

cuisine, Japanese cuisine, and Chinese banquet. The remaining three surveys were conducted during happy hours (18:00 to 20:00) at pubs and a karaoke.

2.5.5 The selection of the wet markets was made after discussions were held with the Housing management.

2.5.6 The study at the Mass Transit Railway (MTR) covers both the platforms and concourses at selected stations during the most crowded periods. The monitoring at train compartments included trains travelling from the Tsuen Wan, Lam Tin and Island lines during peak and off-peak hours under normal operational conditions.

2.5.7 The distribution of the public places surveyed by location is shown as in Table 2-7.

Table 2-7 Distribution of the Public Places Surveyed (unit surveyed by location)

Location	Shopping mall / Department Store	Cinemas	Restaurants	Wet market
Hong Kong Island				
Ap Lei Chau				2
Causeway Bay	1	1	3	
Central			3	
Happy Valley			1	
North Point			1	
Sheung Wan	1			
Tai Koo Shing			1	
Wan Chai		1	8	
Kowloon				
Lam Tin	1			
Lok Fu	1			
Mong Kok		1		
Shatin	1	1		
Shek Kip Mei			1	
Tsim Sha Tsui		1	2	
New Territories				
Kwai Fong	1			
Shatin	1			
Sheung Shui	1			
Tsuen Wan	1			
Total	**8**	**5**	**20**	**2**

2.6 Factors Affecting IAQ

2.6.1 The following are the major factors affecting indoor air quality:

i. Physical factors, e.g., building design, age, location, floor level and occupation density.
ii. Mechanical ventilation and air conditioning (MVAC) system.
iii. External factors, e.g., outdoor air quality and cross contamination.
iv. Factors other than air pollutants, e.g., temperature, humidity, lighting and noise.
v. Interior decorative materials, furnishings and equipment, human activities, and microbial contamination.

2.6.2 *Physical Factors*

2.6.2.1 The issues concerning building design and maintenance which have significant impact on the indoor air quality are: energy-saving measures, floor layout and occupant density as well as building maintenance.

2.6.2.2 Energy saving requirements may inadvertently compromise indoor air quality. In modern office buildings, certain walls consisting of tinted glass is used in the exterior windows which helps to reduce the penetration of solar heat by approximately 40%. Reflective

PM3006517324

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

(mirrored) glass is even more effective as it can reduce solar heat gain by as much as 70%. These buildings are air-tight and have no openable windows.

2.6.2.3 The ASHRAE / IES 90.1-1989 guidelines contained in the "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings" have formed the basis for drafting the energy saving requirements of air conditioning installations in Hong Kong. However, the revised BSR/ASHRAE Standard 62-1989R (ASHRAE, 1996) proposed a new set of minimum supply rate (MSR) for each space served by the ventilation system. The MSR shall be either 100% outdoor air or a mixture of outdoor air and recirculated air. It is necessary to ensure that the minimum supply air rate to any space shall be the larger of 7.5 L/s per person, based on the design occupancy, and the design ventilation rate, adjusted for the air change effectiveness of that space. The method of calculations is detailed in Appendix II. Since July 1997, the revised ASHRAE standard has been placed on hold and the current status of the original ASHRAE standard is also uncertain[1].

2.6.2.4 The requirement for a minimum outdoor air volume is a way to promote energy saving. However, putting such a requirement into practice may not be as straight forward. The concern are: i) the adequacy of the design, ii) outdoor air quality, and iii) the efficiency of filtration or the impedance to air flow.

2.6.2.5 Energy saving devices such as off-hour control on air conditioning may have adverse effect on IAQ because turning off ventilation can cause accumulation of air pollutants such as radon and VOCs. Occupants may be exposed to excessive levels of pollutants when they resume work in these premises. In hot and humid climates, especially Hong Kong where air tight buildings rely on air conditioning, switching off of the system will tend to induce the growth of fungi if building openings are not closed to minimise outdoor air and humidity infiltration. Long weekend are particularly vulnerable to these growths and once the spores proliferate, they are there to stay.

2.6.3 *Mechanical Ventilation and Air Conditioning (MVAC) System*

2.6.3.1 MVAC systems is a common contributing factor to IAQ problem. It has also been recognised as "reservoirs" and "amplifiers" for micro-organisms. Ventilation is necessary to replace stale or contaminated interior space air with "clean" air. Such performance is determined by the "ventilation efficiency", which is the degree of mixing between supply air and interior space air; and to remove pollutants rapidly from interior air space. Concentration of air contaminants in indoor environments directly depends on the effective indoor volume, that is the actual volume available for contaminant dispersion and is dependent on the degree of air circulation.

2.6.3.2 Common MVAC failures implicated in IAQ problems usually refer to: insufficient outdoor air introduced to the system, poor distribution/ stratification of supply air in occupied space, draughtiness (due to improper terminal settings) or stuffiness (due to not enough air delivery or not delivered properly), improper pressure differences, temperature extremes (too hot or too cold), humidity extremes (too dry or too humid), poor filtration (dirt, bugs or pollen in air delivery system), poor maintenance on components such as filters, humidifying systems, and heat exchangers.

2.6.3.3 The MVAC system failure may be due to settled water in system, visual evidence of slime or mould, improper balance of distribution system, dampers at incorrect positions, terminal diffusers not at correct positions or VAV systems in non-delivery or low-delivery mode. The MVAC system may also pose problem when makeup air, design or installation and maintenance are inadequate, or it is not operated properly. Poor maintenance of ventilation system filters can become a source of contamination or become plugged and reduce air flow. The cleanliness of humidifying and dehumidification systems is an important factor to prevent the growth of harmful bacteria and fungi. Condensation occurred during

PM3006517325

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

dehumidification or "latent" cooling often collects in drain pans which should have sufficient pitch so that water drains completely. Stagnant water in the drain pan is a notorious amplification site for microbes.

2.6.4 *External Factors Affecting IAQ*

2.6.4.1 Several external factors may affect IAQ. They include outdoor pollution, radon and pesticides spraying.

2.6.4.2 One of the difficulties in assessing the impact of outdoor air is the lack of outdoor data apart from the criterion pollutants. In Hong Kong, there are very few data on toxic volatile organic in the atmosphere. Hence, measurements were undertaken in parallel with sampling of outdoor air during the IAQ study. However, the positions of air intake for air conditioned buildings are mostly found at high levels and sometimes it may not be always possible to place sampling equipment at the same elevation.

2.6.5 *Factors Other Than Air Pollutants*

2.6.5.1 Thermal comfort can have a profound impact upon the perception of indoor air quality. Temperature in the range of 20 - 26 °C is generally thought to be an acceptable thermal comfort range, depending upon occupational activity, clothing, and relative humidity (ASHRAE-55-1992). Temperatures above this range may increase the initial out-gassing of VOC from materials and may trigger emissions from the sponge effect phenomenon.

2.6.5.2 For Hong Kong, the outdoor RH in the summer can be as high as 100% while RH in the 90% region is frequently encountered. Thus, a well functioning MVAC system would be beneficial to the occupants. The Hong Kong Government Labour Department recommended that the relative humidity (RH) should be maintained between 40 to 70% for Hong Kong which has a typical sub-tropical climate of hot and humid conditions for nine months of the year. It is known that high values (above 70%), particularly associated with high temperature are uncomfortable and facilitate the growth of microbes. Very low humidity (<20%) is also not desirable as it causes drying of mucous membranes or skin.

2.6.5.3 The CoP for Energy Efficiency recommends that when mechanical refrigeration or other energy-consuming processes are used to dehumidify the room air, the control setting should not be set lower than 50% RH. However, it is not the intention of the CoP to limit the RH to 50% in summer. For example, if the room RH falls below 50% due to the room conditions such as the presence of computer equipment only with no human occupancy, it is acceptable. The same applies to limiting the control setting for energy-consuming processes to raise the relative humidity of room air in winter. It is acceptable if room RH goes above 50% in winter because of the presence of a lot of people but it is not acceptable to artificially raise the room RH above 50% by turning on the steam humidifier to increase room humidity beyond 50%.

2.6.5.4 Artificial lighting may cause visual stress, for example, inappropriate levels of lighting, inadequate contrast, and excessive glare may cause eye irritation and headache, which are symptoms commonly associated with poor IAQ.

2.6.5.5 Noise and vibration has also been implicated in producing symptoms similar to those attributable to indoor air pollution. Occupants may experience symptoms of dizziness and irritability which may be perceived to be caused by indoor air quality but instead, have been shown to correlate with vibration[2]. It is also known that low frequency noise (20 to 100 Hz) found in buildings containing HVAC equipment can also cause problems.

2.6.6 *Materials and Equipment Affecting IAQ*

PM3006517326

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

2.6.6.1 Some materials and equipment are known to emit VOCs. They are categorised into two major groups: building materials and furnishings and equipment. Building materials which may affect IAQ include wall paper and covering, paints, tiles, caulking compounds, carpet and all mineral products. However, furnishing materials such as particle board, chipboard, plywood and polyurethane are also known to affect IAQ. In addition, office equipment (e.g., photocopying machine and laser printer) or office stationery such as adhesive tape, glue, correction fluid and marker pen may also affect IAQ. In addition, the fixer used in pesticides for pest control may also emit VOCs.

2.7 Sources of Indoor Air Contaminants and Their Health Effects

2.7.1 Exposure to air pollutants, acutely or chronically, may result in disease. The nature of this depends on the agent, the site of deposition and the defense mechanisms of the lungs. Airways inflammation is the most common effect but involvement of the lung parenchyma may also occur. Inflammation of the lungs may also cause symptoms in other organs in the body.

2.7.2 Some pollutants may exert different effects at different concentrations or duration of exposure. Furthermore, a mixture of chemical compounds, for example, volatile organic compounds (VOCs), have been suggested to cause multiple combined health effects which are unpredictable in most cases due to inadequate information regarding potential interactions. The inhalation pathway is a major source of entrance of air pollutants into the human body. The following presents an account of the air contaminants which affect IAQ and their potential health effects, details of which are listed in Appendix III.

2.7.3 *Carbon Monoxide*

2.7.3.1 Carbon monoxide (CO) comes from cigarette smoking and combustion. CO has a strong affinity with haemoglobin. It is about 200 times as effective as oxygen in combining with haemoglobin to form carboxyhaemoglobin (COHb). As such, it will affect the ability of the red blood cells in carrying oxygen to the body tissues. Carbon monoxide can have detrimental effects on the heart, lungs and nervous system.

2.7.4 *Carbon Dioxide*

2.7.4.1 The major source is from the respiration of human being in an occupied space. Carbon dioxide is an important indicator for ventilation characteristics in areas where people are present. Already at a slightly raised level around 3%, it may cause headache and tiredness.

2.7.5 *Nitrogen Dioxide*

2.7.5.1 The presence of nitrogen dioxide is associated with high temperature combustion source. NO_2 has significant health effects as it is a deep lung irritant. For chronic exposures, substantial changes in pulmonary function can be demonstrated in normal, healthy adults at or above concentrations of 2 ppm[3].

2.7.6 *Respirable Suspended Particulate (PM_{10})*

2.7.6.1 Dust is ubiquitous and the particulates are of variable sizes. Particulate will have health effects especially when they are in the "respirable" range. Suspended particles in air with a nominal aerodynamic diameter of 10 micrometres (μm) and smaller, are the ones which penetrate into the lower respiratory tract, implicated as causes of and contributors to a wide variety of human health effects. Many indoor sources may generate RSP and it is an important pollutant to measure.

2.7.7 *Environmental Tobacco Smoke (ETS)*

PM3006517327

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

2.7.7.1 ETS is an aged, dilute mixture of side-stream and exhaled mainstream smoke from combustion of tobacco products such as cigarettes, cigars, etc. It is the single largest contributor to indoor air particulate concentrations in office buildings where cigarette smoking occurs; it also contains a long list of potentially hazardous chemicals but usually in very low concentrations.

2.7.7.2 A number of studies have demonstrated that the gaseous phase of ETS accounts for most of the odour and irritation. ETS has been suggested to be a causative agent for lung cancer in non-smoking adults.

2.7.8 *Ozone*

2.7.8.1 Ozone (O_3) is an atmospheric oxidant formed through photochemical reactions of volatile organic compounds and nitrogen oxides. It may be generated by equipment with ultra violet (UV) sources such as photocopiers in the office and is therefore measured as an indoor pollutant. Ozone is an irritant to the pulmonary system. It affects the mucous membranes and other lung tissues. It also affects respiratory function.

2.7.9 *Formaldehyde*

2.7.9.1 Formaldehyde is a gas which emanates mainly from pressed-wood products which contains urea-formaldehyde and phenol-formaldehyde (formaldehyde resins) as bonding material. The concentrations of the pollutants emitted are temperature dependent.

2.7.9.2 Formaldehyde cause irritation to all moist body surfaces, such as the mucous membranes of the eyes and upper respiratory tract even at concentrations below 1.2 mg/m^3 (about 1 ppm)[4], though the odour threshold may actually be as low as 0.06-0.07 mg/m^3 (49-57 ppb). Higher levels of formaldehyde exposure are associated with more serious cardiovascular and pulmonary effects, neurological effects, and even cancer.

2.7.9.3 The US National Institute of Occupational Safety and Health (NIOSH) has implicated formaldehyde emissions as the causative agent in 4% of the incidents of building-related illness (BRI) that NIOSH has investigated[5]. It is an important indoor air pollutant to monitor.

2.7.10 *Radon*

2.7.10.1 Radium (a member of the uranium decay series) is present in various concentrations in all rocks and soils. Radium decays to radon enters into the air or dissolves into surrounding water. Radon has a short half-life of less than four days. Radon and its daughters are the highest single source of background radiation; other sources include cosmic rays and other naturally occurring radioactive matter.

2.7.10.2 The dose of radioactivity to the lung from radon is due predominantly to alpha particles that are released by radon daughters. Alpha particles are thought to penetrate the epithelial lining of the lung and damage the genetic material of basal cells[6].

2.7.10.3 Indoor radon is the most significant source of ionising radiation for the general public. There is increasing concern that it is a causal factor in respiratory cancer among both smokers and non-smokers.

2.7.11 *Volatile Organic Compounds (VOCs)*

2.7.11.1 VOCs are a diverse group of carbon-containing compounds that evaporate at room temperature and become airborne. They are also one of the most dynamic classes of indoor air contaminants.

2.7.11.2 Floor coverings are sources of a wide variety of indoor air contaminants such as, VOCs, fibres (including asbestos), and biological contaminants such as mites, bacteria and fungi. Some floor coverings, especially carpets, also act as sinks for pollutants from other sources,

PM3006517328

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

adsorbing the pollutants onto their surfaces or absorbing pollutants into their fibres and later releasing them into the air. Bayer and Papanicolopoulos[7] analysed 30 carpet samples and found 32 frequently emitted VOCs. It is reported that formaldehyde was the most common compound emitted from 277 building materials (including 14 carpets) in a 0.06m^3 environmental study chamber [8].

2.7.11.3 Equipment used in the office may present emissions problems. Laser printers and other computer printers emit hydrocarbons and ozone; and computer terminals, fax machines and other electrical equipment emit ozone and VOCs. Research indicates that in wet-process photocopying, approximately 0.241 g (0.322 ml) of solvent were released with each copy made by a wet-process photocopier. With average usage, the ambient concentration of TVOCs in the copying area were found to be below 1,800 mg/m^3 suggested by the manufacturers to be the "recommended exposure limit".

2.7.11.4 Wet-process photocopying requires the use of toners, dispersants, and developers that are nearly pure aliphatic hydrocarbon petroleum distillate solvents with some trace compounds. Often the solvents are principally composed of isodecane ($C_{10}H_{22}$)[9]. Other VOCs detected include xylene, 2,2,4-trimethyl octane, branched alkanes (C_{10}-C_{11}), nitropyrene, phthalates, and isocyanates. However, the use of dry-process photocopying machines is generally a minor source of particulate except in buildings with high intensity of use of such equipment.

2.7.11.5 The health impacts of exposure to the VOCs emitted from office equipment are similar to those for non-formaldehyde VOC emissions from office furnishings. Exposure to such emissions have been suggested to relate to the "laser printer rhinitis" and the "plotter syndrome" due to the use of laser printers and plotters. These are related to allergic response to the alkyphenol novalac resin in carbonless paper and spasms of the pharyngeal constrictor muscles.

2.7.12 *Pesticides*

2.7.12.1 In addition to accidental poisoning and the possibility of carcinogenic potential, pesticides are now implicated in adverse responses of the immune, nervous, endocrine, and reproductive systems. According to the research reviewed by Consumers Union (USA), insecticides are the most toxic form of pesticides, followed by herbicides, acaricides (mite killers), and fungicides[10].

2.7.12.2 Insecticides are present in many indoor environments and they are attached to dust particles in the air. Some of them are highly volatile. The regular pest control programmes conducted by pest-control contractors could result in the presence of pesticides in the indoor air, and should be monitored.

2.7.13 *Biological Pollutants*

2.7.13.1 Biological pollutants include bacteria, fungi, viruses, spores and allergens generated by biotic or natural organisms and processes. Micro-organisms (microbes) are ubiquitous. Bio-contamination is common in MVAC system, particularly where stagnant water accumulates, such as humidifiers, drip pans and drain pans. Moisture accumulation on dusty units, induction units, cooling coils, and flooding and other water damage can turn these components into microbial reservoirs [11].

2.7.13.2 Human have to contend with the vast number of microbes every day. However, the exposure to these microbes may not necessarily result in overt clinical manifestations because of the immune system. Yet, microbial contamination in air can cause illness through infection, inflammation or allergic reaction. Common infections caused by airborne organisms include Legionnaire's disease, colds, and influenza.

2.7.14 *Bacteria*

PM3006517329

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

2.7.14.1 *Staphylococcus, Micrococcus* and *Streptococcus* represent 85-90% of bacteria isolated in indoor environments[12]. Others include *Bacillus, Pseudomonas, Aeromonas, E. Coli,* and *Mycobacterium tuberculosis*. According to Rylander[13], the major gram-negative bacteria in indoor air are: *Enterobacter agglomerans, Pseudomonas syringae and Klebsiella pneumoniae*. Gram-negative bacteria grow in pools of water such as the reservoirs of humidifiers. In order for them to become aerosolised, physical forces are needed such as vacuum cleaning or, most commonly, operation of a humidifier.

2.7.14.2 Where high counts of bacteria comprise mainly gram-positive bacteria associated with skin-scales shed by occupants they can be regarded as indicators of inadequate ventilation. However, if gram-negative bacteria, such as *Pseudomonas aeruginosa*, or *Thermophilic Actinomycetes* are prominent, a potential health risk is implicit. Routine sampling of *Legionella* is not recommended, but again where it is found there is an implicit health hazard. *Legionella* instead should be systematically searched for in water reservoirs of HVAC, where the conditions for its growth are met.

2.7.14.3 Biological pollutants may cause infectious diseases, allergy and irritation. In fact, respiratory infections account for 50 - 60% of all the community-acquired illness. Indoor transmission of infectious disease depends upon three variables: i) presence of a susceptible population, ii) sufficient concentration of infectious agent in the air, and iii) plausible route of exposure.

2.7.15 *Fungi*

2.7.15.1 Fungi include the filamentous moulds and single-cellular, asexually producing yeasts. They affect human health through their spores, mycotoxins and VOC emissions.

2.7.15.2 The major fungi in indoor air are: Cladosporium, Alternaria, Penicillium, Trichoderma, Aspergillus, Stachybotrys atra, and Mucor.

2.7.15.3 Both bacteria and fungi are important indoor pollutant agents which may be counted or speciated to give information on indoor air quality.

2.7.16 *Endotoxins*

2.7.16.1 Endotoxins are lipopolysaccharide compounds present in the outer cell wall of gram-negative bacteria and blue-green algae. They cause inflammation in the lung when inhaled and affect the immune system[14]. Endotoxins are often present in the water reservoir of humidifiers when the water is contaminated with gram-negative bacteria. They can release their endotoxin into the water, where levels up to 3 μg/ml have been recorded. In the air, levels of 0.5 - 0.8 $\mu g/m^3$ have been measured when contaminated humidifiers have been operating[15]. Endotoxins are measured to give an indication of bacterial contamination.

2.7.17 *(1,3)-β-D-Glucans*

2.7.17.1 (1,3)-β-D-glucans are polyglucose compounds that are part of the structure of the cell wall of moulds and certain bacteria. They have important immunomodulating properties and particularly influence macrophages, causing a delayed effect[16]. After exposure, an increased secretion of lysosomal enzymes can persist up to 30 to 40 days[17]. A synergistic effect between inhaled endotoxin and (1,3)-β-D-glucan has been demonstrated[18]. Glucan is recommended for measurement as it will represent the effect of fungal exposure and expresses the number of alive and dead spores.

2.7.18 *Dust Mites*

2.7.18.1 Dust mites are arachnids (related to spiders, rather than insects) that range in size from about 225-425 μm, and weigh about 2-13 μg, depending on the species and sex of the individual. Commonly found dust mites in buildings include *Dermatophagoides farinae*,

PM3006517330

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Dermatophagoides pteronyssinus and *Euroglyphus maynei*. It is found that dust mites are more than four times as prevalent in residences with wall-to-wall carpeting as in those with bare floors[19].

2.7.18.2 Dust mites are often abundant in upholstered furniture. It favours a temperature of about 77°F (25°C) and relative humidity above 45%. Dust mites are generally not found in surface dust above the floor level since there are not usually enough human skin cells there to sustain their growth. The droppings, shedding and even dead mites are sources of allergic causing agents.

2.8 On-site Survey Parameters

2.8.1 From the information on factors affecting IAQ and sources of significance, the on-site measurements were determined. They comprise physical and chemical measurements as well as samples collected for microbial study :

Ventilation	Air change and air flow-rate & air pressure
Comfort factor	Temperature Relative humidity Air movement (draught)
Real-time measurement	CO CO_2
Integrated sample	Formaldehyde (HCHO) NO_2 Ozone RSP Nicotine
VOCs	Benzene Carbon tetrachloride Chloroform o-Dichlorobenzene Ethyl benzene Tetrachloroethylene Toluene Trichloroethylene o-Xylene m,p-Xylene
PESTICIDES	Organophosphorous
BIOLOGICAL POLLUTANTS (Airborne/dustborne)	Bacteria Fungi Endotoxin Glucan Dust-mite

2.8.2 Apart from the analytics, the following parameters have been considered in the IAQ survey:

- physical conditions of building, e.g., building design, age, location, floor level and area/size, occupancy density
- floor/space usage (including any food service/outlet); exterior construction (e.g., stone panelling); glazing elements (e.g., use of single panel); any record of fire or water damage
- office type (e.g., open office concept), layout of the study area
- mechanical ventilation and air conditioning (MVAC) systems
- external factors, e.g., outdoor air quality and cross contamination
- type of partition (particle board tends to emit VOCs & formaldehyde)
- floor, wall and ceiling, interior decorative materials, furnishings and equipment
- the frequency of pest control

PM3006517331

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

- factors other than air pollutants which are also referred to as "comfort factor", e.g., temperature, humidity, lighting and noise

2.9 Design of Questionnaire Survey

2.9.1 The questionnaire design follows closely that of NIOSH with appropriate adjustments made based on the local factors. The telephone survey was first conducted covering 3,000 household telephone numbers. This survey is complementary to the selection of the 40 office buildings according to the building characteristics and technical framework of IAQ.

2.9.2 The general information collected includes the following:

- occupants' acceptability rating of indoor air quality
- occupants complaint of SBS through their own perception

2.9.3 Factors to be considered in the survey design of the questionnaire survey:

- a selection of personal information such as gender, age, occupation, smoking habits, history of medical conditions including skin allergies and asthma
- occupants' working environmental conditions including present and retrospective environmental conditions, e.g., building related symptoms, which were experienced by occupants during the month preceding the survey
- the occupants' well being and medical condition including sickleave over the past month prior to the survey
- other aspects of the office environment; including details related to the ventilation system, e.g., availability of any air cleaning equipment and whether windows are openable as well as the type of ventilation available during over-time work
- potential emissions from indoor sources e.g., office equipment such as laser printer and photocopier machine and their location from the occupants workstations
- occupants' detection of distinctive odour present during the survey and retrospective (up to three month prior to the survey)
- smoking and eating policy of the office and whether occupants smoke or eat at the workstations
- occupants' perception of indoor climate (e.g., winter and summer temperature) and air quality, dust and noise levels as well as lighting in the workplace
- perception of occupants on air quality of public places identified for the study
- IAQ is the result of the interaction of the various factors. Chemical measurements of the pollution load, for example, CO_2 will be raised with higher occupancy rate and/or inadequate ventilation. This can be a problem in modern buildings where little natural ventilation is available. When the CO_2 level is not properly controlled, it may lead to other IAQ related problems, such as growth of microbial pollutants. Thus, a strategy has been drawn up to measure pollutants generated by various sources
- arising from the building structure, furnishings and ventilation. For evaluation purpose, measurements were taken in the morning. Measurements taken later part of the day have been used for comparison. The ventilation system was turned off after office hour.
- pollutants generated by the occupants or the occupants activities (including the use of office equipment
- climatic factors affecting indoor air quality

PM3006517332

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

2.10 Conclusion

2.10.1 A representative sample of forty office premises was selected according to a pre-set matrix.

2.10.2 The sample covered a total of thirty-four private office buildings, comprising twenty-three, ten and one of Class A, B and C respectively. The remaining six are government owned buildings, four of which belonged to public utility companies. In the selected offices, the proprietors or building owners actually agreed to participate in the IAQ study.

2.10.3 Public places have been considered as a pilot study. They comprised : eight shopping mall/centres, five cinemas, twenty restaurants and two wet markets. In addition, the MTR train compartments and concourse areas were also included. All samples obtained for analysis at these public places were randomly selected except for a few of the cinemas and restaurants which had been previously identified by interviewees on the telephone questionnaire surveys as being very poor in air quality.

2.10.4 Sources which may influence indoor air quality are determined by research. The possible emission sources and their health impacts on the occupants are identified. The information was subsequently used in the design of the questionnaire survey and the on-site survey parameters and they were also used in the study discussed in Chapters 3 and 4.

PM3006517333

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

1 Building Services Journal, CIBSE, September, 1997, p.8.

2 Burt, T.S. 1995. Scoring System for Rating "Sick" Buildings, pp. 231-234. In Morawska. L., Bofinger, N.D., and Maroni, L., (edited) "Indoor Air in Integrated Approach".

3 Manahan , Stanley E. Gaseous Inorganic Air Pollutants. *Environmental Chemistry*. 5th Ed. pp. 269-293.

4 Baird, J.C., et al., (1991), Formaldehyde in the Indoor Air of Non-Industrial Buildings. *Indoor Air Quality for People and Plants*, ed. by Baird, J.C., et.al., Stockholm, Sweden : Swedish Council for Building , Research, pp. 97-109.

5 Melius, J., et al. (1984), Indoor Air Quality : The NIOSH Experience, *Journal of the American Conference of Governmental and Industrial Hygienists*, Vol. 10 : pp. 3-7.

6 Sameet, J., Marbury, M and Spengler, J. (1988). Health Effects and Sources of Indoor Air Pollution. Part II. Am.Rev. Respir. Dis. 137:221-242.

7 Bayer, Charlene W. and C.D.Papanicolopoulos. 1990. Exposure assessments to volatile organic compound emissions from textile products. *Indoor Air '90 : Proceedings of 5th International Conference on Indoor Air Quality and Climate.* Vol. 3. pp. 725-730.

8 Engström, Kerstin. 1990. Building materials : a source of indoor air pollution. *Indoor Air '90 : Proceedings of 5th International Conference on Indoor Air Quality and Climate.* Vol. 3. pp. 677-681.

9 Kerr, G., and Sauer, P., (1990), Control Strategies for Liquid Process Photocopier Emissions, *Indoor Air '90 : Proceedings of the Fifth International Conference on Indoor Air Quality and Climate, Toronto, Canada*, Vol. 3, pp. 759-64.

10 Consumer Union, (1996), "Pest Management at the Crossroads", Professional Mailing and Distribution Services, Inc., 288 pp.

11 Morey, P.R., (1988), Microorganisms in buildings and HVAC systems : A summary of 21 environmental studies. *Proceedings of the ASHRAE Conference IAQ '88 : Engineering Solutions to Indoor Air Problems*. pp. 10-24.

12 Stetzenbach, L.D., (1994), Microbiology of indoor environments. *Proceedings of Assessing Microbiological Contamination of Indoor Environments*. Fairgas, Virginia, USA. Mid-Atlantic Environmental Hygiene Resource Center, Philadelphia, Pennsylvania, USA.

13 Rylander, R., (1995), Respiratory Disease Caused by Bioaerosols - Exposure and Diagnosis, *Fungi and Bacteria in Indoor Air Environments*, pp. 45-55.

14 Rylander, R., and Snella, M.C., (1983), "Endotoxins and the Lung : Cellular Reactions and Risk for Disease" *Clin Allergy* 14:109-112.

15 Rylander, R., and Haglind, P. (1984), Airborne Endotoxins and Humidifier Disease, *Clin Allergy* 14: 109-112.

16 Di Luzio, N.R., (1985), "Update on the immunomodulating activities of Glucans", Springer Semin Immunopathol 8:387-400.

17 Lew, et.al., (1986), "Induction of Macrophage Lysosomal Hydrolase Synthesis and Secretion by (1,3)-β-D-glucan", Cellular Immunol 100:340-350.

18 Fogelmark, B., et.al., (1994), "Pulmonary Inflammation Induced by Repeated Inhalations of (1,3)-β-D-glucan and endotoxin", *Int J Exp Path* 75:85-90.

19 O'Rourke, M.K., L. Fiorentino, D. Clark, M. Ladd, S. Rogan, J. Carpenter, D. Gray, L. McKinley and E. Sorensen, (1993), Building characteristics and importance of house dust mite exposure in the Sonoran Desert, USA. *Proceedings of Indoor Air '93 : 6th International Conference on Indoor Air Quality and Climate.* Vol. 4. pp. 155-160.

PM3006517334

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

3. QUESTIONNAIRE SURVEY

3.1 Introduction

3.1.1 This chapter focuses on the two questionnaire surveys, namely a telephone and an on-site questionnaire survey that have been executed to investigate general white collar worker's perception on IAQ, health symptoms, various determining parameters such as building characteristics, ventilation, activities and habits of the occupiers as well as their opinion on IAQ in public places. The questionnaires are contained in Appendix IV.

3.2 Telephone Survey (TS)

3.2.1 Prior to the carrying out of the actual telephone survey, a "pilot telephone survey" was conducted by the experienced interviewers of the Social Science Research Centre (SSRC) using the 20 channel Computer Assisted Telephone Interviewing System (CATIS) on 5 February 1996 and monitored by officers of the EPD and the Study Team members. A pilot study was performed to try out the system and to assess the feasibility and the practicality of the questionnaire. The questionnaire was slightly modified after the review and discussion with EPD and the Advisors to the study.

3.2.2 The telephone survey was conducted under the direction by Dr. John Bacon-Shone, Director of SSRC of the University of Hong Kong from February to May 1996. The TS was conducted by trained interviewers of the SSRC using the CATIS from 18:00 to 22:30 hours during weekdays, and from 14:00 to 22:30 during weekends. The system offers Chinese display of the purposely designed questionnaire and the interviewers were required to key in the answer directly into the computer as the survey went on.

3.2.3 The survey was designed to cover at least 1,000 office premises throughout the territory. Over 4,000 numbers were randomly generated from all registered household telephone numbers of Hong Kong. From a total of 3,657 attempts, 2,007 (54.88%) successful cases were obtained with approximately 40% of the respondents agreed to disclose the identity of their office buildings.

3.3 On-Site Questionnaire Survey (OS)

3.3.1 A total of 40 commercial buildings were randomly selected from the initial 1,000 premises identified from the TS for detailed on-site survey. The selection was intended to match the matrix as set forth in Chapter 2, designed to cover various building types and age, geographical location, and MVAC systems.

3.3.2 The on-site questionnaire survey was based on all the occupants of the 40 selected commercial buildings and their work areas where on-site indoor air quality measurements were also taken. A structured questionnaire (which was similar to the one used in the TS) was used for the on-site survey and was distributed to the occupants of the room around the area where the measurements were taken; and then collected by a survey administrator. The survey period coincided with the site measurement and it stretched over almost a year in some cases

PM3006517335

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

when longitudinal study with seasonal variations was undertaken. In total, there were 1,184 questionnaires returned with a response rate of 89%.

3.4 Criteria for Random Selection of Respondents

3.4.1 The same pre-qualification criteria have been adopted for both the telephone and the on-site questionnaire survey which included :-

- The respondent works in an office/commercial building environment
- The respondent stays in his/her office for at least two-third of the total working hours per week, (i.e. at least 27 hours/week)
- The workplace is served by air conditioning system
- The respondent has his/her own workstation in the office

3.5 Questionnaire Design

The design of the questionnaires was based on the National Institute for Occupational Safety and Health (NIOSH) questionnaire with appropriate adjustments for the local situations in Hong Kong.

3.5.1 Sections 1 and 2: Personal Profile

Questions in these sections were set to obtain information on personal and medical background of the respondent, e.g., age, education level, smoking habits and whether they have been diagnosed with any medical conditions. These might become confounding factors and they have been used later in the Statistical Analysis Stage.

3.5.2 Section 3: Workplace Condition, Ventilation, Policy on Smoking and Eating

Questions were devised to obtain information on workplace condition and workplace operation/equipment. Smoking and eating, in particular cooking in office are identified as factors affecting indoor air quality and sources of common indoor air pollutants.

3.5.3 Section 4: Potential Indoor Air Emissions

This section poses questions on whether there are new building materials used or any refurbishing in the office in the past 3 months. The items referred to are within 3 metres from the workstation of the person participating in the questionnaire survey. Apart from furniture and fixtures, questions also cover the use of office equipment and some stationery.

3.5.4 Section 5: Health and Well-Being of the Respondent

This section looked into the general health and well-being of the respondent including sickleave frequency. Symptoms concerned were adopted from the NIOSH questionnaire with adjustments made based on comments from various medical/ health experts including Professor John Spengler, Dr. James Day, Professor Ragnar Rylander, and Dr. Linda Koo.

3.5.5 Section 6: Occupant's Perception on Indoor Environment

PM3006517336

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

The factors selected included comfort, cleanliness, thermal, humidity and ventilation condition of the workplace; any dust, noise and lighting problems as well as the respondent's direct perception on indoor air quality and the Building Symptom index represented by six questions related to the common Sick Building Syndrome.

3.5.6 *Section 7: Individuals' Recreational Activities and Their Perceptions on Air Quality in Public Places*

This section has been included in order to establish the respondent's opinions on IAQ of public places such as shopping centres, restaurants and cinemas. The questionnaire also covers the respondent's experience of IAQ in MTR stations and train compartment. The respondent's daily routing on MTR would be computed to provide information on the protocol for IAQ studies in MTR compartment during peak hours. In addition, it is considered useful to obtain some public view on IAQ as an environment issue and also to assess public attitude on who should be responsible for the issue. Respondents may indicate if they support the prescribed statements as in an opinion poll.

3.6 Quality Control on Telephone Survey

3.6.1 As a quality control (QC) measure for the TS, 100 samples (5%) of the samples were repeated by call backs to observe variation of the answers and to ensure quality and validity of the feedback. For the purpose of the QC, five factual questions have been selected for the call backs.

3.6.2 The QC was conducted independently by the Consultant and answers from the interviewees were checked against the ones obtained during the TS. The sample was taken as valid only if all five answers matched with the original set. 100% match of the original answers was achieved. No questionnaire was dropped after the independent checking.

3.7 Confidentiality of the On-Site Questionnaire Survey

3.7.1 All identities of the participants had been kept confidential and remained anonymous in the data analysis.

3.8 Results of Both Questionnaire Surveys

This section presents a summary of the major findings from the telephone (T) and on-site (O) questionnaire survey. Results of the entire surveys are tabulated in Appendix V.

3.8.1 *Respondents' Information*

T 48.03% and 51.97% of the respondents were male and female, respectively. The majority of the respondents were aged between 21 to 40 (78.40%) with a mean of 32.49 (standard deviation = 8.79).

O 42.75% and 57.25% of the respondents were male and female, respectively. The majority of the respondents were also aged between 21 to 40 (85.56%) with a mean of 31.25 (standard deviation = 1.15).

PM3006517337

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

T 93.94% of the respondents were employee with only 4.84% of them were owner/ director/ self-employed of the business. 57.96% of the respondents worked in open-planned office with shared private office and single person office constituted 27.23 and 13.18% of the samples, respectively.

O 98.96% of the respondents were employee with only 0.69% of them were owner/ director/ self-employed of the business which was likely due to the priority selection of more densely occupied study areas during the on-site survey. This is in line with the findings that 84.83% of the respondents worked in open-planned office with shared private office and single person office constituted only 8.93 and 4.33% of the samples, respectively.

T 67.81% of the respondents had matriculation or above qualification. Over half of the respondents (64.63%) were non-professional/ managerial/ executive persons with clerk/ secretary/ receptionist was found to be the dominant occupation category (49.03%).

O 44.24% of the respondents had matriculation or above qualification. 62.62% of the respondents were non-professional/ managerial/ executive persons which 49.44% of the respondents were clerk/ secretary/ receptionist.

3.8.2 *Perception on Indoor Air Quality*

T 72.30% of the respondents were satisfied with the indoor air quality of their workplace. Similar trends of findings were observed for questions on comfort and cleanliness of their workplace.

O 61.35% of the respondents were satisfied with the indoor air quality, with 73.94% of them satisfied with comfort and 72.03% satisfied with the cleanliness of their workplace.

3.8.3 *Odour Source*

T Out of the 172 cases of odour problem reported, tobacco smoke and building renovation were found to be the major sources with 48 and 30 cases, respectively.

O A total of 847 cases of odour problem were reported. Tobacco smoke, building renovation, mould, the use cleaning agent and body odour accounted for 114, 95, 100, 85, and 72, respectively.

3.8.4 *Dust Problem*

T 22.65% of the respondents had "some" dust problem in their offices. While most of them did not have any noise problem (68.57%), the majority of them experienced "little" problem (91.19%) with lighting in their offices.

O 29.84% of the respondents had "some" dust problem in their offices. Noise problem was found to be more serious during the on-site survey with only 17.912% of the respondents had no noise problem. Lighting was not found to be a problem with 89.26% of the respondents expressed satisfaction.

3.8.5 *Temperature, Relative Humidity and Draught*

PM3006517338

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Most of the respondents satisfied with the temperature, humidity and draught of their offices for both summer and winter seasons. For the dissatisfied cases, most of them felt too cold, too dry, and too stuffy in both seasons.

3.8.6 *Smoking Habit*

T Amongst the 250 current smokers identified, 34.40% of them smoked at work which represented approximately 4.3% of the total respondents. 74.05% of the total respondents claimed that tobacco smoke bothered them a lot. 33.15% of the respondents said smoking was permitted in their entire office.

O A total of 71 smokers were identified. 47.89% of them smoked at work which represented approximately 2.9% of the total respondents. 78.81% of the respondents claimed that tobacco smoke bothered them a lot. Smoking was permitted in the entire office of 17.09% of the respondents.

3.8.7 *Medical History*

T Only minority of the respondents had records of asthma, hay fever, bronchitis, and mold allergy which constituted 2.17, 16.02, 4.70, and 2.83%, respectively, of the total responses. For the positive answers, further confirmation was made to see if the sicknesses were diagnosed by a doctor and was occurred at his/her present office. The percentages were 1.14, 7.73, 2.22, and 1.41%, respectively, for the above 4 sickness.

O Respondents with records of asthma, hay fever, bronchitis, and mold allergy which constituted 4.32, 4.07, 14.70, and 11.92%, respectively, of the total responses. The percentages of the above sicknesses diagnosed by a doctor and occurred at his/her present office were 0.44, 0.62, 5.91 and 3.76%, respectively.

3.8.8 *Type of Ventilation During Overtime Work*

T 57.34% of the respondents left their office before the central air conditioning system was turned off. Out of the total responses of 947, 10.03% of the respondents claimed to have no mechanical ventilation or window available during over-time work.

O 75.89% of the respondents left their office before the central air conditioning system was turned off. Out of the total responses of 925, 18.16% of the respondents claimed to have no ventilation available during over-time work.

3.8.9 *Air-Cleaning Device* $\frac{186}{2007} * 100 = 9.27$.

T Among the 186 respondents' office (9.46%) who had air-cleaning device installed in their offices, 50.53% of them claimed that there was noticeable improvement of air quality in their office.

$\frac{44}{1184} * 100 = 3.72$

O Among the 44 respondents' office (3.81%) who had air-cleaning device installed in their offices, 86.36% of them claimed that there was noticeable improvement of air quality in their office.

3.8.10 *Openable Windows*

PM3006517339

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

T Among the 32.81% of the respondents who reported openable windows were available in their office, only 69.30% of them could open the windows as they wished.

O Among the 17.53% of the respondents who reported openable windows were available in their office, only 22.61% of them could open the windows as they wished.

3.8.11 *Office Decoration/ Water Damage*

T The occurrence of new carpet, wall painting, furniture, partition, and water damage within 3 metres from the respondents' workstation over the past 3 months was recorded as 4.30, 7.17, 11.64, 4.87, and 10.51%, respectively.

O The occurrence of new carpet, wall painting, wall paper, furniture, partition, and water damage within 3 metres from the respondents' workstation over the past 3 months was recorded as 4.50, 4.58, 3.46, 9.01, 6.15, and 11.07%, respectively.

3.8.12 *Office Equipment*

T For respondents who had office equipment that were potential source of indoor air pollutants in their office, 23.38, 39.06, and 31.52% of them had photocopier, laser printer, and fax machine, respectively, within 3 metres from their work stations.

O For respondents who had office equipment that were potential source of indoor air pollutants in their office, 27.83, 48.75, and 29.01% of them had photocopier, laser printer, and fax machine, respectively, within 3 metres from their work stations.

3.8.13 *Office Stationery*

T For common stationery which were considered potential sources of indoor air pollutants, 77.93% of the respondents used correction fluid more than once a day; while that for marker pen, solvent glue, and carbonless paper were recorded as 44.10, 13.30, and 26.08%, respectively.

O For common stationery which were considered potential sources of indoor air pollutants, 74.57% of the respondents used correction fluid more than once a day; while that for marker pen, solvent glue, and carbonless paper were recorded as 37.44, 10.73, and 23.06%, respectively.

3.8.14 *Sick Building Syndrome Symptoms*

T The frequencies of the respondents on 12 symptoms commonly occurred were obtained which 6 of them were taken into calculation for the Building Symptom index (BSI) as discussed in Chapter 2. The 6 symptoms included eye discomfort, sore/dry throat, headache, fatigue, runny nose, and dry/itchy skin which the former 4 were found to be the most commonly occurring Sick Building Symptoms (SBS) as illustrated in Table 3-1.

PM3006517340

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 3-1 Response of the 6 Building Sickness Symptoms from the Questionnaire Surveys

	Telephone Questionnaire Survey			On-Site Questionnaire Survey		
	Yes	Got Better away from Work	No. of Responses	Yes	Got Better away from Work	No. of Responses
Eye Discomfort	24.00%	15.56%	1,767	54.36%	34.43%	1,159
Runny Nose	7.55%	3.83%	1,801	44.26%	27.34%	1,159
Blocked Nose				36.15%	22.00%	1,159
Sinusitis				6.38%	7.25%	1,159
Sore/ Dry Throat	25.73%	10.83%	1,745	48.32%	28.30%	1,159
Headache	24.17%	13.64%	1,738	50.13%	30.20%	1,159
Dry/ Itchy Skin	12.10%	5.34%	1,760	34.94%	20.45%	1,159
Fatigue	28.13%	19.92%	1,692	61.35%	32.53%	1,159

3.8.15 *Cold/ Flu and Sickness*

T Average days cold/flu per respondent was found to be 0.81 (Standard Deviation = 4.16). 94.30% of the respondents had been sick over the past 30 days with a mean sickness day of 4.96 (Standard Deviation = 6.93). Despite the high sickness record, however, only 20.45% of the respondents had taken sick leave over the period. The mean sick leave over the past 30 days was 0.33 days (Standard Deviation = 1.10).

O Average days cold/flu per respondent was found to be 1.50 (Standard Deviation = 2.86). 59.57% of the respondents had been sick over the past 30 days with a mean sickness day of 2.66 (Standard Deviation = 3.76). Despite the high sickness record, however, only 30.97% of the respondents had taken sick leave over the period. The mean sick leave over the past 30 days was 0.46 days (Standard Deviation = 1.09).

3.8.16 *Perception on IAQ in Public Places*

T The percentages of respondents who expressed dissatisfaction on the indoor air quality in public places including shopping mall, restaurant, and cinema were recorded as 18.37, 44.11, and 28.38%, respectively. 20.39% of the respondents had experience on feeling dizzy while travelling with MTR with 89% of the cases occurred inside train compartment.

O The percentages of respondents who expressed dissatisfaction on the indoor air quality in public places including shopping mall, restaurant, and cinema were recorded as 11.18, 29.78, and 9.68%, respectively. 45.74% of the respondents had experience on feeling dizzy while travelling with MTR with 81% of the cases occurred inside train compartment.

3.8.17 *Building Symptom Index (BSI)*

This is made up of symptoms which go away after work. They are: dry, itching or irritated eyes, runny noise or sinus, sore or dry throat, unusual tiredness (fatigue), headache and dry or itching skin.

T The mean BSI this month recorded from the 2,007 respondents of the telephone questionnaire survey was 0.64 (standard deviation = 1.08).

PM3006517341

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

- The mean BSI this month recorded from the 1,184 respondents of the on-site questionnaire survey was 1.77 (standard deviation = 1.86).

3.9 Conclusion

3.9.1 Occupants could provide information on existing situation representing over 800 buildings (identified) plus at least 500 unknown buildings out of a total of 1,435 office buildings in Hong Kong. The population profile is shown to be representative of the Hong Kong working population in terms of age, gender and education level. The information on occupants' perception is subsequently compared to the measurements performed by the use of correlation analysis. The frequency distribution obtained may by an indication of the individual's susceptibility in some cases. The statistics obtained for each of the variable form the database for the statistical analysis.

PM3006517342

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4. ON-SITE SURVEY

4.1 Introduction

4.1.1 This chapter provides information on the protocols and results of the on-site monitoring and surveys on indoor air quality of offices and public places in Hong Kong.

4.2 Office Premises Survey

4.2.1 A total of 40 office premises were surveyed (see Chapter 2 for details). A one-day survey was conducted at each selected office premises which resembled the common working hours from 9:00 a.m. to 5:00 p.m.

4.2.2 A summary of the characteristics of the 40 office premises included in the survey is enclosed in Appendix VI-1.

4.2.3 Out of the 40 premises, 5 were selected for the longitudinal study. They made up of 3 Class A and 2 Class B offices and they were chosen across the territory (Appendix VI-1). A total of 4 surveys were conducted at each office, including 2 for the summer and 2 for the winter season. The variation of pollutant level between the beginning of the week and normal weekdays were also covered.

4.3 Public Places Surveyed

4.3.1 *Restaurants*

4.3.1.1 The study of a total of 20 restaurants was conducted from May to October 1996 (see Appendix VI-2 for details. It was targeted on the peak hours of each restaurants which included lunch (12:00 to 14:00) and dinner (19:00 to 21:00), and happy hour for pubs and karaoke. Unlike the study of the other places, no parallel outdoor samples were collected for the restaurants surveys.

4.3.1.2 Samples at restaurants were taken over long meals by the field team disguised as clients as most restaurant owners were reluctant to co-operate.

4.3.1.3 There was no restriction in smoking in the surveyed restaurants except some of them had designated area for smoking. For the later case, air samples were collected from the non-smoking area. Relatively higher smoking activities were observed at the 3 pubs.

4.3.2 *Cinema*

4.3.2.1 Indoor air monitoring was conducted during the entire duration of a movie (see Appendix VI-3 for summary of the selected cinemas).

4.3.3 *Shopping Mall*

4.3.3.1 Surveys at shopping malls were conducted from 12:00 to 20:00 on Sunday to capture the most crowded scenario (see Appendix VI-4 for a summary of the 8 surveyed shopping malls). A total of 5 sampling points were chosen at each premises. An additional sampling location was selected at the fresh air intake position to obtain parallel ambient air quality data.

4.3.4 *Wet Market*

PM3006517343

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.3.4.1 The wet markets in Ap Lei Chau area were managed by the Housing Department. A half-day pilot study was conducted on 17 October 1996 with an aim to obtain a general picture on indoor air quality of wet markets. The survey was conducted from 13:30 to 17:30 to cover the peak hour activities in the afternoon.

4.3.5 Mass Transit Railway (MTR)

4.3.5.1 MTR as a mode of transport, provides by far the most efficient service to public who commute to work. The exposure of the public using the MTR service is transient and it will last only as long as the journey (maximum of 1 to 2 hours each day).

4.3.5.2 A survey schedule for MTR platforms and concourses were planned with permission and assistance from the MTRC (see Appendix VII-4).

4.3.5.3 At each MTR station, a series of above-ground ventilation shafts were used to supply fresh air to the underground concourses and platforms. An "enthalpy" control system was employed for energy efficiency by utilising the difference between the indoor and outdoor enthalpy for the control of fresh air intake volume. Control parameters for the operation of the MVAC system included temperature and relative humidity. The system was designed to maintain a minimum of 1/3 air change per hour based on computer model simulation. Constant Air Volume (CAV) was installed at the concourses and platforms to provide constant air conditioning based on manual temperature pre-settings. The air mixing at the platform was mainly relied on the piston effect created when the train travelled through the tunnel.

4.3.5.4 MVAC system of the stations were operated in summer mode during the survey. The mode allowed minimal amount of fresh air to be drawn from the ground by a low power booster fan into the Air Handling Unit (AHU) rooms. After mixing with the return air from the platform or concourse, the air was filtered and cooled down by the AHU prior to delivering to the concourse and platform. In order to reduce the cooling load due to the hot outdoor air during summer, the exhaust vent shafts were closed and large proportion of return air was re-circulated within the station.

4.3.6 Train Compartment

4.3.6.1 Air quality inside the train compartment of the Island Line, Tsuen Wan Line and Kwun Tong Line for both peak and off-peak periods were surveyed (see Appendix VII-5).

4.3.6.2 Each flight of train consisted of eight compartments. Each compartment could carry up to 300 passengers. Two units of roof-mounted packaged type air conditioners were installed inside each train compartment which could supply an air flow of 800 litre/second. The total conditioned air flow was estimated to be 3,500 litre/second. The cooling capacity of each air conditioner at design condition was 40 kW. These flow rates and conditions were specially designed to maintain a temperature of 25°C with relative humidity of 65% inside the train compartment. The conditioned air was distributed to the compartment via the 10 outlet boxes positioned along each side of the train compartment.

4.4 Selection of the Monitoring Method

4.4.1 The parameters for detailed monitoring have been selected on the basis of findings of the previous chapters to account for comfort as well as environmentally health factors, and the characterisation of the Mechanical Ventilation Air Conditioning (MVAC) characterisation.

PM3006517344

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.4.2 The methods of analysis were selected on the criteria that it has a detection limit covering the normal range of indoor air pollution for that particular chemical. The minimum acceptable detection limit was 1% of the occupational exposure standards.

4.4.3 In the selection of analytical method, due consideration had been given to eliminate the possible interference from common agents such as H_2O (water vapour) and preferably be selective of the chemical under study or offers high degree of sensitivity compared to interfering agents. Another criteria for laboratory analysis would be the ease of handling and extensive shelf-life of the sample. In addition, it is preferably that the method had been adopted by similar studies conducted by overseas authorities to allow comparison of the results.

4.5 The Survey Team

4.5.1 The survey team is made up of several members, each designated specific role. In addition, the structure of the Survey and Data Management Team has been identified. The team comprised 7-9 people (see Appendix VII-6).

4.6 Arrangement with the Building Proprietors

4.6.1 One of the most difficult tasks was to convince the targeted building proprietors to participate in the Study by gaining access for the survey. The Project Manager/ Project Co-ordinator approached the building proprietors directly. An invitation letter was issued together with a short description of the Study, measurements to be performed, as well as information and arrangement required by the Building Proprietor. It was agreed that all building identities to be kept confidential and remained anonymous in all reports/ publications.

4.7 Measurement Strategy

4.7.1 The strategy adopted here is to have two sets of analysis done simultaneously; one set for instantaneous measurement using direct reading, portable equipment during the workday, and another set taking an integrated sample which gives a cumulative measurement of pollutant over a fixed period which is subsequently analysed in the laboratory.

4.7.2 The direct reading measurement allows the air quality to be assessed on an hourly basis so that variation in pollution level can be gauged against time. The instantaneous reading offers immediate detection of abnormal situations and hence remedial action on site is possible. This measurement was carried out at all premises for the 8-hour period during normal office hours where activities were being carried out. The integrated sample is able to give an eight-hour average over the work period.

4.8 The Survey Protocol

4.8.1 An initial visit was made by the Field Team Leader to each building premises after the building premises has been selected and recruited into the Study. The objectives of this initial building visit were to verify the suitability of the building premises for the Study, to collect information for the selection of study areas for detailed survey, and to determine appropriate monitoring locations within the study areas.

4.8.2 Subject to the permission of the building proprietor, five most densely occupied indoor study areas were selected from each of the selected premises where MVAC characterisation, comfort and environmental measurements, and occupant response data were collected as part of this protocol.

PM3006517345

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.8.3 A "Sampling and Survey Protocol" along with 21 Standard Operating Procedures (SOPs) of individual parameters has been formulated based on standard methodologies adopted by IAQ researchers and government agencies. A total of 37 checklists were designed to obtain information pertaining to indoor environmental conditions, location and dimension of sources and sinks of typical indoor air pollutants, design, operation and maintenance of the MVAC system, as well as to record all real-time data obtained from the survey.

4.8.4 Air pollutants including in the "World Health Organisation Working Group Consensus of Concern About Indoor Air Pollutants at 1984" except radon and asbestos were covered in the Study. Table 4-1 summarises the parameters and sample collection methods measured during the Study.

Table 4-1 Equipment/ Methods Adopted in the Survey

Parameter	Sampling Method/ Device
Real-Time Monitors	
Air Temperature	AMR Therm 2286-2 Digital Psychrometer
Relative Humidity	AMR Therm 2286-2 Digital Psychrometer
Carbon Dioxide (CO_2)	Brüel & Kjær 1302 Multi-gas Monitor/ Metrosonic Aq-513 Monitor
Carbon Monoxide (CO)	Brüel & Kjær 1302 Multi-gas Monitor
Integrated Samples	
Respirable Suspended Particulates (RSP)	Air Diagnostics constant high volume sampler, size selective impactor, Teflon filter
Volatile Organic Compounds (VOCs)	SUMMA® canister
Formaldehyde	SKC Passive Diffuser
Ozone (O_3)	Ogawa Passive Diffuser
Nitrogen Dioxide (NO_2)	Advantec Passive Diffuser
Nicotine	Pump/ XAD-4 sorbent tube
Viable Microbes	Andersen N6 Sampler, RCS Sampler, Agar plates & strips
HVAC Measurements	
Supply Airflow Rate	1. Duct Traverse using pitot tube or hot wire anemometer 2. Air flow rate at filters using rotating vane type anemometer 3. Summation of air flow rates from supply air grilles using airflow hood
Supply Air Temperature	Psychrometer
Supply Air Relative Humidity	Psychrometer
Outdoor Air Intake Rate	1. Duct Traverse 2. Flow rate approximation by CO_2 ratio using CO_2 monitor
Exhaust Fan Airflow Rate	3. Duct Traverse 4. Summation of airflow rates through exhaust air grilles using air flow hood

4.8.5 Siting of the monitors/ samplers was at locations representing the primary workstation layout and work activities. The general criteria of selecting the monitoring locations within the selected study areas throughout the Study were as follows :

PM3006517346

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

i. Locations were selected to minimise impact on work activities within the area
ii. Locations were at least 0.5 metre from corners or windows
iii. Locations were at least 0.5 metre from walls, partitions, and other vertical surfaces (e.g. file cabinets)
iv. Locations were not directly under or in front of air supply diffusers, induction units, floor fans, or heaters (personal), etc.
v. Locations were not where direct sunlight will impact the instrumentation
vi. Locations in hall ways or passageways were not preferred
vii. Locations were not within 1 metre of localised sources such as photocopiers, printers and cigarette smokers
viii. Locations of instruments were not obstructing or interfering with occupant egress from the study area under normal or emergency situations
ix. Inlets of samplers at indoor locations were placed at a height of 1.1 metre above the floor
x. For the outdoor sampling location, all the monitors and sensors were enclosed in an appropriate shelter to shield from direct sunlight and moisture. Even if poor weather is not expected, the shelter was still used in order to maintain consistent collection conditions.

4.8.6 Air exchange rate of the study areas was determined by tracer gas technique in accordance with the UK Health and Safety Executive Method. Sulphur hexafluoride (SF_6), which is a colourless, odourless gas, was injected into the return air of the study area to allow homogeneous mixing for one hour. During the period, a portable fan was used to provide further mixing at the study areas. In general, SF_6 was present in the study area in a level approximately 2,000 fold less than the Threshold Limit Value (Time-Weighted Average) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) before monitoring. The decay of SF_6 concentration with respect to time was recorded for the evaluation of air exchange rate.

4.8.7 Temperature and relative humidity were recorded by a portable digital psychrometer in accordance with the ASHRAE standard method. Temperature was recorded at three heights of 0.1m, 1.1m and 1.7m above the floor to observe the temperature gradient. Air velocity was determined using an all directional air velocity meter.

4.8.8 Indoor noise was measured at selected premises using a precision integration sound level meter to obtain the average level between five Leq 1-minute measurements. The noise meter used had a precision level of ±0.1 dB and was placed at the centre of the sampling area at 1.1m aboveground using a tripod. The meter was calibrated against the calibrator supplied by the manufacturer every day before measurement. Light intensity was measured by an illuminance meter.

4.8.9 The 3 minutes average level of carbon monoxide, carbon dioxide, formaldehyde and RSP were monitored by real-time monitors carried by a mobile cart at both indoor and outdoor locations on hourly interval. CO and CO_2 were measured based on Non-Dispersive Infra-Red (NDIR) while RSP was measured based on light-scattering principle. The trend of variation of the pollutant levels throughout the day was quantified.

4.8.10 Formaldehyde was sampled by a passive bubbler sampler containing 5ml 0.05% MBTH solution. The vial was then capped with a fresh Knudsen disk and the bubblers is placed upside down at the sampling locations. The minimum formaldehyde level detected with this

PM3006517347

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

method is 10 microgram per cubic meter. The detection limit is about 0.025 ppm for 8-hour exposure.

4.8.11 Nitrogen dioxide (NO_2) was collected by specific passive samplers developed by Harvard School of Public Health throughout the sampling day. The sampler contains a cellulose fibre filter containing triethanolamine as absorbent. After the exposure, the samplers were delivered to the laboratory for analysis by spectrophotometric method. The detection limit is about 14 $\mu g/m^3$ for 8-hour exposure.

4.8.12 Ozone (O_3) was also collected by specific passive samplers developed by Harvard School of Public Health throughout the sampling day. The sampler contains a nitrite-coated filter as absorbent. The samplers were analysed at the laboratory by Ion Chromatography. The detection limit is about 25 ppb for 8-hour exposure.

4.8.13 Respirable Suspended Particulates (RSP) were collected by high volume samplers at a constant flow rate of 10 LPM, equipped with an impactor with cut size at 10 μm, on a pre-weighted 37mm diameter Teflon filter. In order to minimise the disturbance to the occupants, the pumps were housed inside a sound proof box designed by the manufacturer. The pumps were warmed up for 10 minutes prior to commencement of each sampling.

4.8.14 Volatile Organic Compounds (VOCs) including benzene, carbon tetrachloride, trichloroethylene, tetrachloroethylene, chloroform, dichlorobenzenes, ethylbenzene, toluene and xylenes were determined in accordance with the USEPA TO-14 Method. Summa canisters were cleaned, leak tested, and certified by the appointed laboratory with flow controller pre-set at a rate of approximately 8 ml/min. At the site, each canister was labelled and checked by a digital flowmeter prior to sampling. The samples collected throughout the day were delivered to the laboratory for cryogenic pre-concentration and GC-MS analysis. Such method has a detection limit of sub-ppb level for specific VOC.

4.8.15 Nicotine sampling was only performed at the premises with known record of smoking in accordance with the NIOSH Method. The sampling train comprises of an air sampler calibrated at a constant rate of 1 LPM and a XAD sorbent tube. The collected samples were delivered to the laboratory for GC-NPD analysis.

4.8.16 Organophosphorus pesticides were determined in accordance with the NIOSH Method at office premises where records of pest control were available. Air was sampled actively by OVS-2 sampler through a low-volume sampler calibrated at a constant flow of 1 LPM. The collected samplers were delivered to the laboratory for GC-FPD analysis. A total of 16 organophosphorus pesticides were determined.

4.8.17 Common biological contaminants including fungi and bacteria were determined at both indoor and outdoor locations in accordance with the ACGIH Guidelines for Bioaerosols Assessment. Malt extract agar (MEA) with rose bengal was used for fungi and plate count agar (PCA) with cycloheximide is used for mesophilic bacteria. Culture media were delivered to the laboratory immediately after sampling and incubated at 25 °C for 6 days for fungi and 35 °C for 2 days for bacteria. The colonies of bacteria and fungi were counted separately. Fungi samples were verified by species by light microscopy such that the presence of any toxigenic species was identified. The comparison between the outdoor and indoor fungi levels provided useful information on the nature of the contaminant.

PM3006517348

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.8.18 Aerobiological contaminants were collected by an Andersen 6-stage Microbiological Impactors at a constant flow rate of 28.3 LPM for 4 minutes as soon as the sampling session began. The sampler was designed to collect and to size the particles aerodynamically into 6 categories in relation to the human lung deposition, ranging from above 7 μm entering at the nose to approximately 0.65 to 1.1 μm entering the alveoli. The pump flow rate was checked by the NIST-traceable rotameter before and after each sampling session.

4.8.19 The present of visible moulds and potential reservoirs for the growth of microbial, such as drain pans, were inspected. Swab samples were taken at locations where microbial were suspected to grow with a sterilised cotton swab soaked with Ringer solution. The collected samples were placed into a sterile universal bottle, labelled and sent to the laboratory for analysis. Airborne dust was collected for endotoxin and (1,3)-ß-D-glucan determination at randomly selected premises.

4.8.20 MVAC measurements include determination of the flow rates of fresh air, supply and return air to the study areas by either duct traverse using pitot tube, rotating vane type anemometer, or a digital flow hood, depending on site conditions. Inspection of MVAC system, filters and exhaust fans, measurements of temperature, relative humidity, CO_2 levels at the fresh air supply and return air ducts were taken using real time monitors.

4.8.21 *Independent Review*

4.8.21.1 The Harvard team came in early June, 1996, before the commencement of the core study for a week and audited the entire process to ensure the protocols were proper and procedures were followed. A report on quality assurance was submitted by the Team to EHS.

4.8.21.2 The Steering Group also witnessed a full-day survey at the Murray Building and the Consultants were able to answer the queries they had.

4.8.22 *Video and Photos Taken On-Site*

4.8.22.1 A video and sound recording was produced on the on-site survey with detailed verbal explanation on the entire process. The video was shown to the Steering Group on June 3, 1996. A two-volume photo album was prepared to provide records of the sampling locations.

4.8.23 Quality Control

4.8.23.1 In order to ensure the quality of the deliverables, a four-tier quality control programme was formulated which included the following:

i. Review of the study strategy by a team of world-renowned experts
ii. Review of the survey protocol and on-site performance of the survey team by representatives from the Harvard School of Public Health
iii. Quality control of equipment and laboratories involved in the survey
iv. Internal quality control

4.8.23.2 A "Quality Assurance Project Plan" was also prepared based on ISO 9001 requirements which included sample preparation and handling, calibration, data processing, as well as requirements for laboratory analysis. Approximately 10% of the total samples were performed for quality assurance/ quality control including duplicate samples, field blanks and spike. Standard gas cylinders were available for zero and span check of CO and CO_2.

PM3006517349

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.8.23.3 Calibration of sampling pumps was done using a film bubble electronic calibrator. All calibrators were traceable to NIST standards. Any discrepancy on flow rates was corrected accordingly during data interpretation.

4.9 Results of the Office Surveys

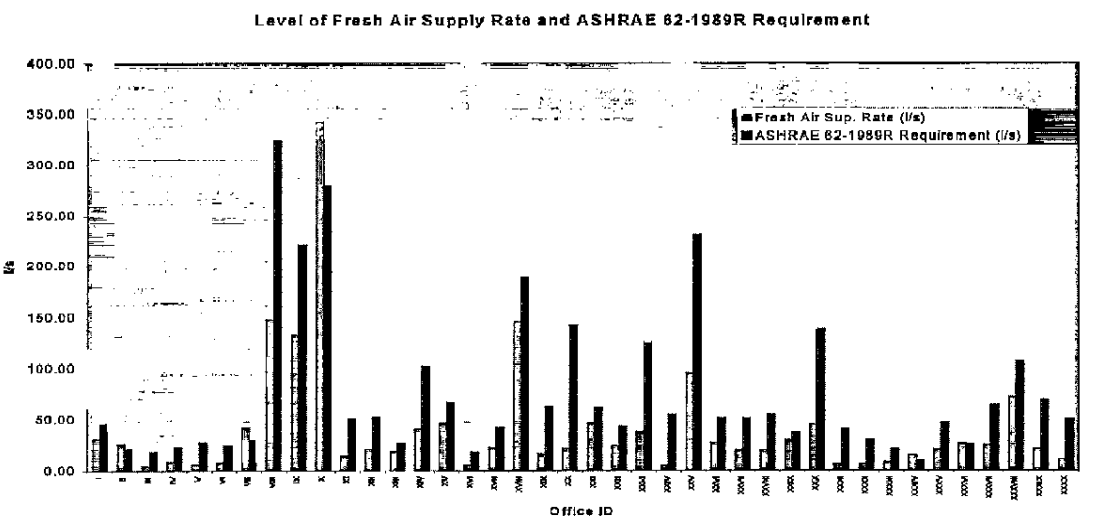
4.9.1 The results reported in this section were compared to internationally accepted standards and guideline by ASHRAE and WHO where available; in the absence of such standards, a 5% value of TLV-TWA is used. They are referred to as the IAQ-objective which will be elaborated in Chapter 8.

4.9.2 *Fresh Air Supply*

4.9.2.1 Fresh air supply requirements calculated in accordance with the ASHRAE 62-1989R standard of the 40 office premises ranged from 11.35 to 324.0 l/s (mean = 77.11 l/s, standard deviation = 74.74 l/s).

4.9.2.2 Fresh air supply rates of the 40 office premises measured by tracer gas technique were found to range from 4.52 to 341.42 l/s (mean = 41.64 l/s, standard deviation = 60.66 l/s). The existing fresh air supply rate of the 40 office premises were found to be between 9.60% to 129.86% of the ASHRAE 62-1989R requirement (mean = 58.30%, standard deviation = 33.89%) (see Figure 4-1).

Figure 4-1 Level of Fresh Air Flow Rate and ASHRAE 62-1989R Requirement



4.9.3 Temperature

4.9.3.1 The average indoor temperature of the 40 office premises was found to range from 20.95 to 24.58 °C during the core study in summer (mean = 22.26 °C, standard deviation = 0.82 °C).

4.9.3.2 The study found that only 7 of the 40 offices (17.5%) satisfied with the standard IAQ-objective for room temperature of 23-26 °C for summer. The average indoor temperature of the remaining 33 offices were found to be below the comfort range (too cold). Such finding is in line with the results of the telephone survey which most of the respondents who dissatisfied with the indoor temperature felt too cold in their offices. It should be

PM3006517350

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

noted that the IAQ-objective for temperature is based on the ASHRAE 55-1992 Standard which is based on a 10% dissatisfaction criterion.

4.9.3.3 The average outdoor temperature at the fresh air intake position were found to range from 22.75 to 35.25 °C (mean = 29.02 °C, standard deviation = 2.30 °C).

4.9.3.4 The average vertical temperature differences between the measurements taken at 1.7m and 0.1m above ground were found to range from 0.6 to 3.0°C, with a mean difference of 1.50°C (Standard Deviation = 0.60°C). While all the mean temperature difference had achieved the Standard Plus Class of the IAQ-Objective (<3°C), 4 of the office failed to achieve the Premier Class objective (<2°C).

4.9.4 Relative Humidity

4.9.4.1 The average indoor relative humidity for the 40 office premises during the summer survey was found to range from 48.72 to 71.72% (mean = 60.07%, standard deviation = 4.96%). 20 of the office (50%) had mean indoor relative humidity (RH) below 60% which satisfied the IAQ-objective. A total of 19 of the remaining offices had mean indoor RH between 60 to 70%, while 1 of the offices had mean indoor RH above 70%.

4.9.4.2 The average outdoor relative humidity for the 40 office premises during the summer survey was found to range from 43.50 to 98.00% (mean = 72.62%, standard deviation = 10.09%).

4.9.5 Draught

4.9.5.1 The average draught for the 40 office premises during the summer survey was found to range from 0.006 to 0.326 m/s (mean = 0.0525 m/s, standard deviation = 0.0488 m/s). Only 1 of the offices (OFF-II) had mean air movement exceeding the standard IAQ-objective of 0.25 m/s.

4.9.6 Carbon Monoxide

4.9.6.1 Real-time carbon monoxide (CO) were measured at all 5 study locations on an hourly basis throughout the survey period. The study found that offices without restriction on smoking (i.e., 13) had a mean indoor CO level of 1,067 $\mu g/m^3$ (standard deviation of 587) whereas those with smoking restrictions (i.e., 32) show a mean of 770 $\mu g/m^3$ and standard deviation of 370.

4.9.6.2 Another source of CO had been reported to have come from carparks in the same building drawn in by the piston effect of elevators. The levels of CO were as high as 18 ppm in the office space drawn in from the carpark with a level of 150-200 ppm in the carpark[1].

4.9.6.3 The average outdoor CO levels at the fresh air intake points of the 40 office premises in the summer survey were recorded to range from 604 to 2,926 $\mu g/m^3$ (mean was 1,214 $\mu g/m^3$ and standard deviation was 452 $\mu g/m^3$). None of the fresh air intake points of the 40 office buildings was seriously affected by emission from road traffic and/or carparks.

4.9.7 Carbon Dioxide

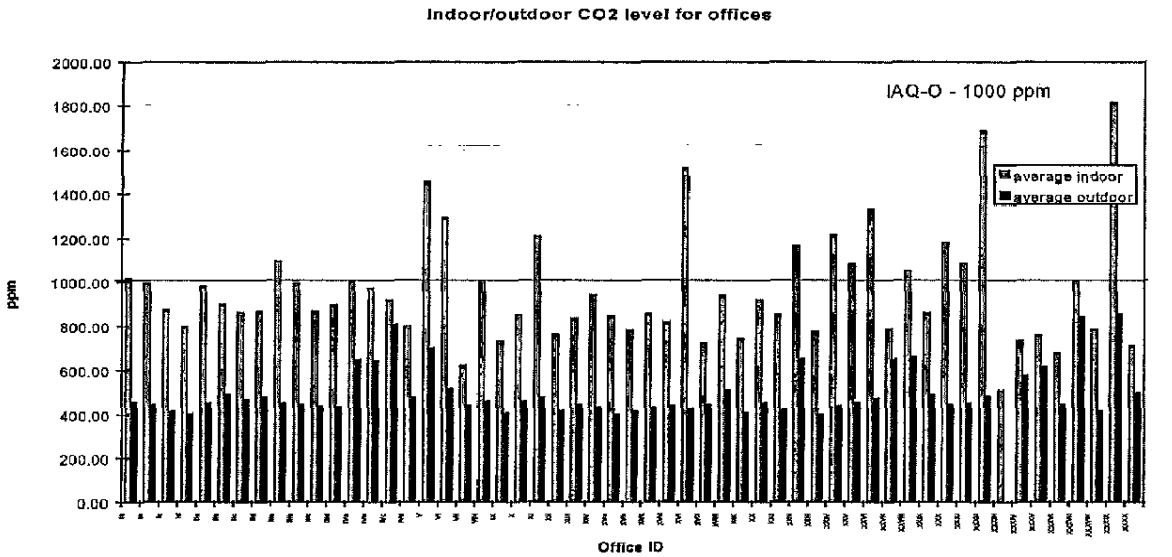
4.9.7.1 Real-time carbon dioxide (CO_2) was measured throughout the 8-hour workday on an hourly basis. The level rises as the office starts work until lunch hour when occupants leave the premises for an one-hour lunch break. The level then rises as the afternoon session resumes, usually reaching the maximum before the end of the workday.

PM3006517351

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.9.7.2 In the summer survey, 15 of the surveyed office premises (37.5%) had mean CO_2 level exceeding the IAQ-objective of 1,000 ppm while 70% had their maximum CO_2 levels exceeding the standard, some as high as 2,000 ppm (see Figure 4-2).

Figure 4-2 Level of CO_2



4.9.8 *Formaldehyde*

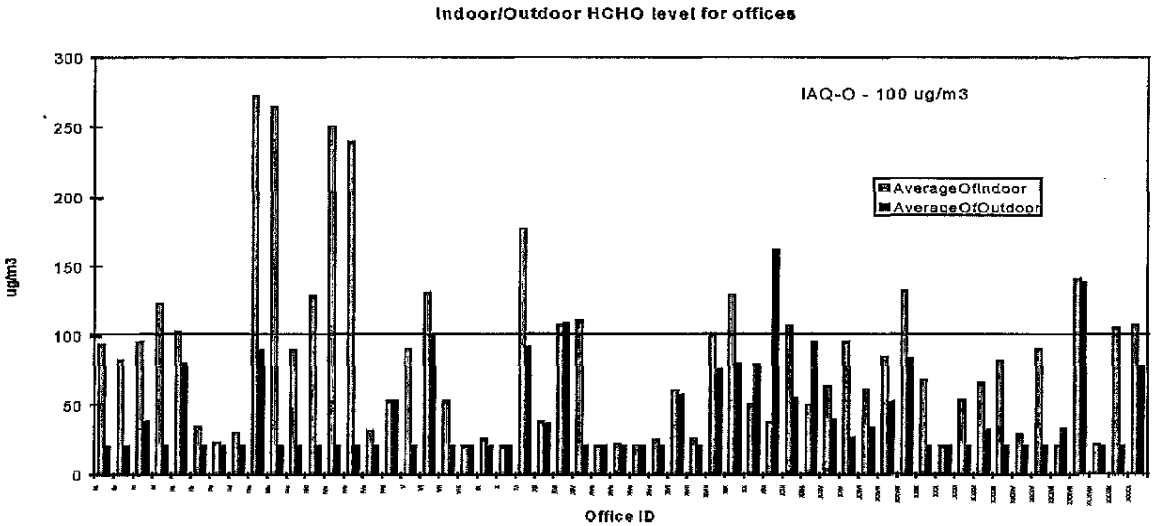
4.9.8.1 The average indoor formaldehyde levels of the 40 office premises involved in the summer survey were found to range from below detection limit (21 $\mu g/m^3$) to 177.0 $\mu g/m^3$. The average outdoor formaldehyde levels recorded at the fresh air intake position ranged from below detection limit to 162.2 $\mu g./m^3$ (mean = 45.3 $\mu g/m^3$, standard deviation = 35.5).

4.9.8.2 The study showed a total of 13 office premises (32.5%) where formaldehyde levels were above the standard IAQ-objective of 100 $\mu g/m^3$ during the summer (see Figure 4-3). The levels were expected to be higher if new particle-board furniture and/or formaldehyde coated fabrics/carpets have been recently installed.

Figure 4-3 Level of Formaldehyde

PM3006517352

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001



4.9.9 Nitrogen Dioxide (NO_2)

4.9.9.1 The average indoor NO_2 levels at the 40 office premises during the summer survey were found to range from 4.2 to 49.6 $\mu g/m^3$ (mean = 19.0 $\mu g/m^3$, standard deviation = 10.9 $\mu g/m^3$). All the recorded mean indoor NO_2 levels were below the standard IAQ-objective of 150 $\mu g/m^3$ as no source of combustion was identified in the surveyed premises.

4.9.9.2 The average outdoor NO_2 levels at the fresh air intake of the 40 premises during the summer survey were found to range from 7.9 to 217.0 $\mu g/m^3$ (mean = 71.1 $\mu g/m^3$, standard deviation = 45.3 $\mu g/m^3$).

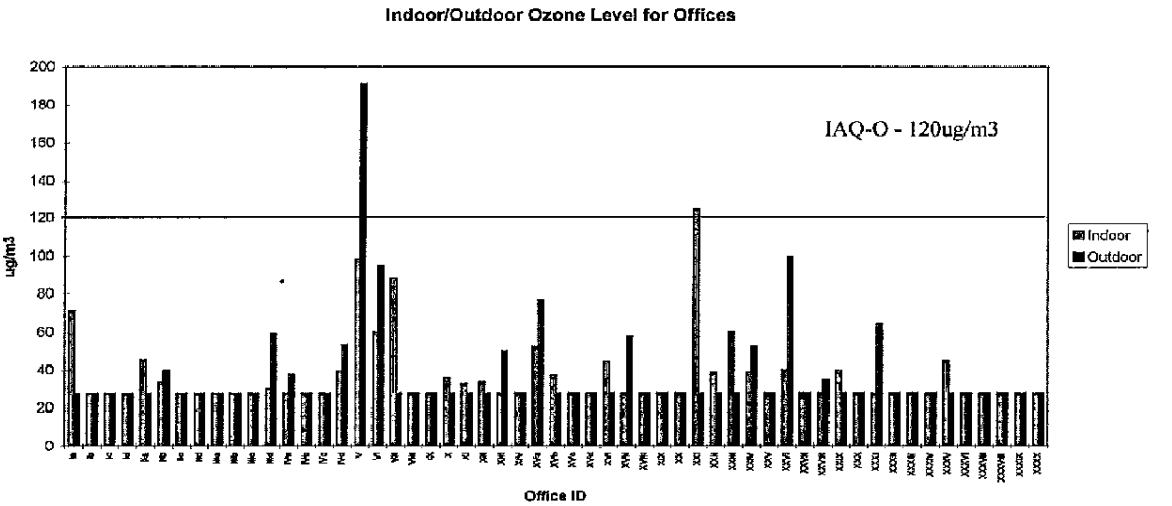
4.9.9.3 The mean indoor/ outdoor ratio was found to be 0.34.

4.9.10 Ozone (O_3)

4.9.10.1 The average indoor O_3 levels at the 40 office premises during the summer survey were found to range from below detection limit (<27.48 $\mu g/m^3$) to 124.6 $\mu g/m^3$ (mean = 37.3 $\mu g/m^3$, standard deviation = 20.3 $\mu g/m^3$). While only 17 of the offices had indoor ozone level above the detection limit, one of the offices (Office XXI) had average O_3 level above the standard IAQ-objective of 120 $\mu g/m^3$ (see Figure 4-4). The amount of O_3 emission increases with the age of the photocell. Most new photocopying machines were equipped with charcoal filters and O_3 emissions were very low.

Figure 4-4 Level of Ozone

PM3006517353
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001



4.9.10.2 The average outdoor O_3 levels at the fresh air intake of the 40 premises during the summer survey were found to range from <27.48 to 190.9 μg/m^3 (mean = 39.3 μg/m^3, standard deviation = 29.3 μg/m^3).

4.9.10.3 The mean indoor/ outdoor ratio was found to be 1.12.

4.9.11 Respirable Suspended Particulates (RSP)

4.9.11.1 The average indoor RSP levels at the 40 office premises during the summer survey were found to range from 6.8 to 163.6 μg/m^3 (mean = 29.7 μg/m^3, standard deviation = 24.2 μg/m^3). All the recorded mean indoor RSP levels were below the standard IAQ-objective of 180 μg/m^3. Even though their outdoor levels may be high in certain areas in Hong Kong, fresh air intake is usually located at a high level (roof of podium). The use of filters also helps to reduce the indoor levels.

4.9.11.2 The average outdoor RSP levels at the fresh air intake of the 40 premises during the summer survey were found to range from 10.8 to 266.6 μg/m^3 (mean = 65.9 μg/m^3, standard deviation = 58.4 μg/m^3).

4.9.11.3 The mean indoor/ outdoor ratio was found to be 0.66. In this IAQ study, RSP is the only parameter where its indoor level is very much influenced by outdoor level.

4.9.12 *Nicotine*

4.9.12.1 Nicotine was found at offices with records of smoking with levels ranged from below detection limit (<0.95 μg/m^3) to 5.26 μg/m^3. All the recorded mean indoor nicotine levels at the surveyed offices are well below the standard IAQ-objective of 6.8 μg/m^3.

4.9.13 *Volatile Organic Compounds (VOCs)*

4.9.13.1 The measurement of 12 VOCs in this study includes benzene, carbon tetrachloride, chloroform, o,m,p-dichlorobenzene, ethylbenzene, tetrachloroethylene, toluene, trichloroethylene, and o,m,p-xylene. Results indicated that the levels of VOCs recorded were generally well below 5% of the respective TLV-TWA limit and threshold odour level for normal offices. For offices affected by renovations in the vicinity, the group of solvents

PM3006517354

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

used as thinners (toluene, xylene and benzene) showed exceptionally high levels and some even exceeded the IAQ-objective.

4.9.13.2 The average indoor benzene levels recorded in the 40 offices during the summer survey were found to range from below detection limit (<0.32 $\mu g/m^3$) to 102.1 $\mu g/m^3$ (mean = 6.6 $\mu g/m^3$, standard deviation = 15.2 $\mu g/m^3$). The high levels were found in premises adjacent to offices undergoing renovation. The average outdoor benzene levels recorded at the fresh air intake position of the offices ranged from <0.32 to 19.14 $\mu g/m^3$ (mean = 2.25 $\mu g/m^3$, standard deviation = 3.37 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 16.1$\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for benzene was 5.62.

4.9.13.3 The average indoor carbon tetrachloride levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.63 $\mu g/m^3$) to 2.05 $\mu g/m^3$ (mean = 0.78 $\mu g/m^3$, standard deviation = 0.30 $\mu g/m^3$). The average outdoor carbon tetrachloride levels recorded at the fresh air intake position of the offices ranged from <0.63 to 2.52 $\mu g/m^3$ (mean = 0.76 $\mu g/m^3$, standard deviation = 0.37 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 103 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for benzene was 1.13.

4.9.13.4 The average indoor chloroform levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.21 $\mu g/m^3$) to 2.43 $\mu g/m^3$ (mean = 0.52 $\mu g/m^3$, standard deviation = 0.51 $\mu g/m^3$). The average outdoor chloroform levels recorded at the fresh air intake positions of the offices ranged from <0.21 to 1.45 $\mu g/m^3$ (mean = 0.27 $\mu g/m^3$, standard deviation = 0.21 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 163 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for chloroform was 2.23.

4.9.13.5 The average indoor o-dichlorobenzene levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.60 $\mu g/m^3$) to 4.21 $\mu g/m^3$ (mean = 1.08 $\mu g/m^3$, standard deviation = 0.75 $\mu g/m^3$). The average outdoor o-dichlorobenzene levels recorded at the fresh air intake positions of the offices ranged from <0.60 to 9.02 $\mu g/m^3$ (mean = 1.46 $\mu g/m^3$, standard deviation = 1.84 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 500 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for o-dichlorobenzene was 1.42.

4.9.13.6 The average indoor m-dichlorobenzene levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.60 $\mu g/m^3$) to 22.70 $\mu g/m^3$ (mean = 2.79 $\mu g/m^3$, standard deviation = 4.27 $\mu g/m^3$). The average outdoor o-dichlorobenzene levels recorded at the fresh air intake positions of the offices ranged from <0.60 to 31.26 $\mu g/m^3$ (mean = 2.14 $\mu g/m^3$, standard deviation = 4.81 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 500 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for o-dichlorobenzene was 3.31.

4.9.13.7 The average indoor p-dichlorobenzene levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.60 $\mu g/m^3$) to 72.45 $\mu g/m^3$ (mean = 14.03 $\mu g/m^3$, standard deviation = 16.84 $\mu g/m^3$). The average outdoor o-dichlorobenzene levels recorded at the fresh air intake positions of the offices ranged from <0.60 to 39.08 $\mu g/m^3$ (mean = 4.34 $\mu g/m^3$, standard deviation = 8.00 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 200 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for o-dichlorobenzene was 9.39.

PM3006517355

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.9.13.8 The average indoor ethylbenzene levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.43 $\mu g/m^3$) to 455.2 $\mu g/m^3$ (mean = 20.45 $\mu g/m^3$, standard deviation = 70.1 $\mu g/m^3$). The average outdoor ethylbenzene levels recorded at the fresh air intake positions of the offices ranged from <0.43 to 203.8 $\mu g/m^3$ (mean = 7.56 $\mu g/m^3$, standard deviation = 31.24 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 1,447 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for ethylbenzene was 11.90.

4.9.13.9 The average indoor tetrachloroethylene levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.68 $\mu g/m^3$) to 15.95 $\mu g/m^3$ (mean = 2.95 $\mu g/m^3$, standard deviation = 3.41 $\mu g/m^3$). The average outdoor tetrachloroethylene levels recorded at the fresh air intake positions of the offices ranged from <0.68 to 18.33 $\mu g/m^3$ (mean = 1.95 $\mu g/m^3$, standard deviation = 3.19 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 250 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor tetrachloroethylene ratio was 2.54.

4.9.13.10 The average indoor toluene levels recorded from the 40 offices during the summer survey were found to range from 4.05 to 3,113.7 $\mu g/m^3$ (mean = 247.76 $\mu g/m^3$, standard deviation = 598.51 $\mu g/m^3$). The highest level of 18.25 mg/m^3 was observed in an office with redecoration work nearby and was excluded from the calculation of mean. The average outdoor toluene levels recorded at the fresh air intake positions of the offices ranged from below detection limit (<0.38 $\mu g/m^3$) to 331.12 $\mu g/m^3$ (mean = 40.15 $\mu g/m^3$, standard deviation = 68.68 $\mu g/m^3$). All other recorded levels were below the IAQ-O of 1,092 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor toluene ratio was 15.71.

4.9.13.11 The average indoor trichloroethylene levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.54 $\mu g/m^3$) to 995.0 $\mu g/m^3$ (mean = 29.15 $\mu g/m^3$, standard deviation = 149.13 $\mu g/m^3$). The average outdoor trichloroethylene levels recorded at the fresh air intake positions of the offices ranged from <0.54 to 28.6 $\mu g/m^3$ (mean = 2.07 $\mu g/m^3$, standard deviation = 4.78 $\mu g/m^3$). All the recorded levels were below the IAQ-O of 770 $\mu g/m^3$ (8-hour average). Elevated trichloroethylene levels were recorded at all sampling locations of Office-VI where a printing machine was located at the centre of the office. The mean indoor/ outdoor trichloroethylene ratio was 10.1.

4.9.13.12 The average indoor o-xylene levels recorded from the 40 offices during the summer survey were found to range from 0.87 to 216.77 $\mu g/m^3$ (mean = 14.91 $\mu g/m^3$, standard deviation = 37.3 $\mu g/m^3$). The average outdoor o-xylene levels recorded at the fresh air intake positions of the offices ranged from below detection limit (<0.43 $\mu g/m^3$) to 104.05 $\mu g/m^3$ (mean = 4.9 $\mu g/m^3$, standard deviation = 16.58 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 1,447 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for o-xylene was 13.26.

4.9.13.13 The average indoor m,p-xylene levels recorded from the 40 offices during the summer survey were found to range from below detection limit (<0.43 $\mu g/m^3$) to 586.36 $\mu g/m^3$ (mean = 35.91 $\mu g/m^3$, standard deviation = 94.97 $\mu g/m^3$). The average outdoor m,p-xylene levels recorded at the fresh air intake positions of the offices ranged from <0.43 to 307.81 $\mu g/m^3$ (mean = 13.19 $\mu g/m^3$, standard deviation = 48.21 $\mu g/m^3$). All the mean recorded levels were below the IAQ-O of 1,447 $\mu g/m^3$ (8-hour average). The mean indoor/ outdoor ratio for m,p-xylene was 21.68.

PM3006517356

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.9.13.14 Details of the parameters measured during the on-site surveys providing high, low and mean values as well as percentiles (50, 75 and 95 percentile levels) are shown in Appendix XII.

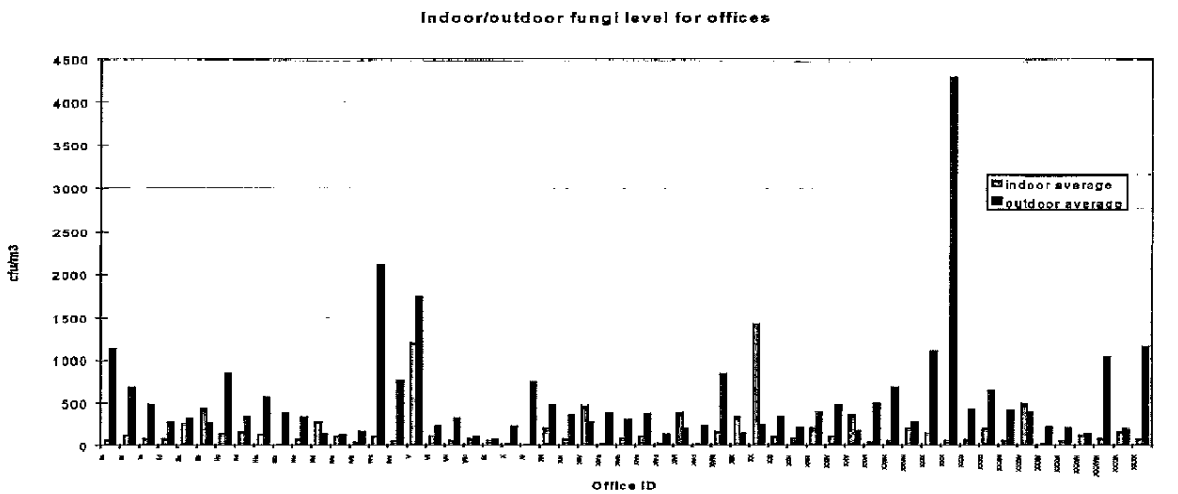
4.9.14 Pesticides

4.9.14.1 The Study found that frequency of the application of pesticide for pest control ranged from once every 1 to 6 months at 28 offices. Residue organophorsphorus pesticide was found at 11 offices in low levels including diazinon, chlopyrifos, and triphenyl phosphate.

4.9.15 *Fungi*

The average indoor airborne fungi levels recorded at the 40 office premises during the summer survey were found to range from 13.5 to 1,415 cfu/m3 (mean = 186.9 cfu/m3, standard deviation = 270.96 cfu/m3). Two of the 40 offices (5%) had indoor airborne fungi above 500 cfu/m3 (see *Figure 4-5*).

4.9.15.1 *Figure 4-5 Level of Fungi*



4.9.15.2 The average outdoor airborne fungi levels recorded at the fresh air intake position of the office premises during the summer survey ranged from 71 to 4,276 cfu/m^3 (mean = 565.36 cfu/m^3, standard deviation = 700.59 cfu/m^3). The mean indoor/ outdoor airborne fungi ratio was 0.62. Seven of the 44 office samples had airborne indoor/ outdoor fungi ratio above 1.0 which suggests possible presence of an amplifier in the indoor environment.

4.9.15.3 The following species of toxigenic and pathogenic fungi were identified during the survey. *Aspergillus flavus* is a fungi of both toxigenic and pathogenic in nature.

Toxigenic : *Aspergillus flavus, Aspergillus versicolor, Aspergillus ochraceous, Penicillium aurantiogriseum, Penicillium brevicompactum, Penicillium viridicatum,* and *Penicillium crustosum*

Pathogenic : *Aspergillus flavus* and *Aspergillus fumigatus*

4.9.15.4 A total of 8 offices had toxigenic/ pathogenic fungi species found in their indoor environment with percentage ranged from 1.3 to 50% (mean = 12.25%, standard deviation = 11.73%).

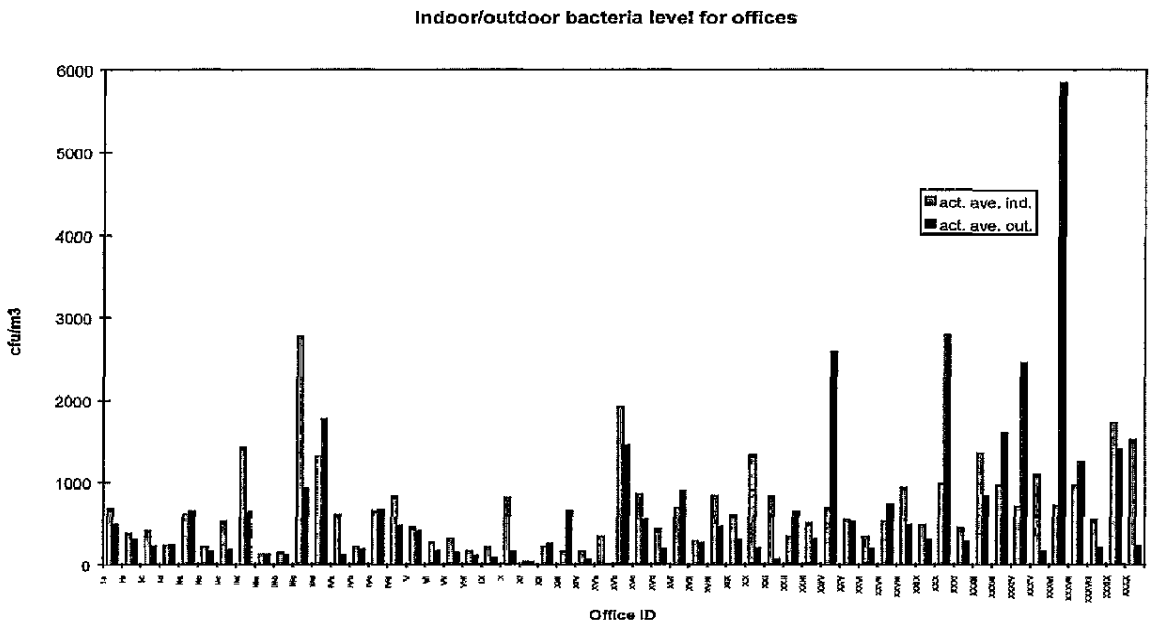
PM3006517357
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.9.15.5 The average indoor dust-borne fungi levels at the 40 offices during the summer survey were found to range from 9.7 x 10^2 to 4.8 x 10^7 cfu/g of dust (mean = 2.33 x 10^6 cfu/g, standard deviation = 8.62 x 10^6 cfu/g).

4.9.16 Bacteria

4.9.16.1 The average indoor airborne bacteria levels recorded at the 40 office premises during the summer survey were found to range from 39 to 2,777 cfu/m^3 (mean = 739 cfu/m^3, standard deviation = 541.6 cfu/m^3). 8 of the 40 offices (20%) had indoor airborne bacteria above 1000 cfu/m^3 (see Figure 4-6).

Figure 4-6 Level of Bacteria



4.9.16.2 The average outdoor airborne bacteria levels recorded at the fresh air intake position of the office premises during the summer survey were found to range from 36 to 5,847 cfu/m^3 (mean = 768.0 cfu/m^3, standard deviation = 1,042.4 cfu/m^3). The mean indoor/ outdoor airborne bacteria ratio was 2.03. 13 of the 44 office samples had airborne indoor/ outdoor bacteria ratio above 1.0.

4.9.16.3 The average indoor dust-borne bacteria levels at the 40 offices during the summer survey were found to range from 9.0 x 10^4 to 1.4 x 10^8 cfu/ m^3 of dust (mean = 9.79 x 10^6 cfu/ m^3, standard deviation = 2.45 x 10^7 cfu/g).

4.9.17 Endotoxin

4.9.17.1 The airborne endotoxin levels of the 52 samples collected from the 40 office premises were all below the detection limit of 0.12 ng/m^3. Hence none of the sample was above the International Commission of Occupational Health (ICOH) guideline of 10 ng/m^3 for toxic pneumonitis and airways inflammation. Endotoxin, however, was found in the 5 dust

PM3006517358
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

samples with levels ranged from 135 to 1,114 ng/g (mean = 610.6 ng/g, standard deviation = 481.8 ng/g).

4.9.18 *Glucan*

4.9.18.1 The airborne glucan levels of the 52 samples collected from the 40 office premises ranged from below detection limit (<0.12 ng/m^3) to 2.57 ng/m^3 (mean = 0.68 ng/m^3, standard deviation = 0.54 ng/m^3). None of the sample was above the provisional guideline of 10 ng/m^3 [1]. Glucan was also found in the 5 dust samples with levels ranged from 2,279 to 10,484 ng/g (mean = 5,134 ng/g, standard deviation = 3,319.2 ng/g).

4.9.19 Dust Mite Allergen

4.9.19.1 Dust mite allergen was monitored in the dust samples collected from 20 offices. The average indoor dust mite allergen levels were found to range from below detection limit to 46.87 µg/g dust (mean = 8.33 µg/g dust, standard deviation = 12.60 µg/g dust). Three of the samples had dust mite allergens level between 2-10 µg per l/g dust which is considered "significant" with risk for sensitisation and bronchial hypersensitivity. Five of the samples had dust mite level above 10 µg per l/g dust which is considered "high" with risk for acute asthmatic attack.

4.9.20 *Noise*

4.9.20.1 Indoor noise levels recorded from 9 of the 40 surveyed office premises were found to range from 38.8 to 67.8 dB(A) (mean = 52.42 dB(A), standard deviation = 4.44 dB(A)).

4.9.21 *Illuminance*

4.9.21.1 Indoor illuminance levels recorded from 9 of the 40 surveyed office premises were found to range from 20 to 1,000 lux (mean = 468.35 lux, standard deviation = 158.03 lux).

4.10 Results of the Longitudinal Study

4.10.1 *Temperature*

4.10.1.1 The mean indoor temperature of the 5 office premises were found to be 22.05 °C (standard deviation = 0.38 °C) and 22.32 °C (standard deviation = 0.80 °C) for the summer survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 0.99 (standard deviation = 0.03).

4.10.1.2 The mean indoor temperature of the 5 office premises were found to be 20.67 °C (standard deviation = 1.25 °C) and 21.22 °C (standard deviation = 1.11 °C) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 0.97 (standard deviation = 0.01).

4.10.1.3 The mean indoor temperature of the 5 office premises for all summer and winter surveys were 22.18 °C (standard deviation = 0.53 °C) and 20.94 °C (standard deviation = 1.17 °C), respectively. There was no significant difference between mean indoor temperature in summer and winter with a summer/winter ratio of 1.06 (standard deviation = 0.06) was obtained.

[1] Rylander, R., (1997), Private Communication.

PM3006517359

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.10.1.4 The mean indoor temperature of the 5 office premises for all surveys before and after holidays were 21.36 °C (standard deviation = 0.64 °C) and 21.77 °C (standard deviation = 0.87 °C), respectively. There was no significant difference between mean indoor temperature before and after holidays with a before/after holiday ratio of 0.98 (standard deviation = 0.02) was obtained.

4.10.2 *Relative Humidity*

4.10.2.1 The mean indoor relative humidity of the 5 office premises were 60.58% (standard deviation = 5.52%) and 60.87% (standard deviation = 6.01%) for the summer survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was found to be 1.00 (standard deviation = 0.02).

4.10.2.2 The mean indoor relative humidity of the 5 office premises were found to be 62.60% (standard deviation = 12.61%) and 63.40% (standard deviation = 7.63%) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 0.98 (standard deviation = 0.11).

4.10.2.3 The mean indoor relative humidity of the 5 office premises for all summer and winter surveys were 60.73% (standard deviation = 5.74%) and 63.00% (standard deviation = 9.79%), respectively. There was no significant difference between mean indoor relative humidity in summer and winter with a summer/winter ratio of 0.99 (standard deviation = 0.20) was observed.

4.10.2.4 The mean indoor relative humidity of the 5 office premises for all surveys before and after holidays were 61.59% (standard deviation = 6.01%) and 62.14% (standard deviation = 5.04%), respectively. There was no significant difference between mean indoor temperature before and after holidays with a before/after holiday ratio of 0.99 (standard deviation = 0.06) was observed.

4.10.3 Carbon Monoxide (CO)

4.10.3.1 The mean indoor CO levels of the 5 office premises were found to be 683.73 $\mu g/m^3$ (standard deviation = 331.96 $\mu g/m^3$) and 872.02 $\mu g/m^3$ (standard deviation = 445.30 $\mu g/m^3$) for the summer survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 0.90 (standard deviation = 0.51).

4.10.3.2 The mean indoor CO levels of the 5 office premises were found to be 1,642.49 $\mu g/m^3$ (standard deviation = 986.31 $\mu g/m^3$) and 1,484.59 $\mu g/m^3$ (standard deviation = 887.02 $\mu g/m^3$) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was found to be 1.21 (standard deviation = 0.43).

4.10.3.3 The mean indoor CO levels of the 5 office premises for all summer and winter surveys were 777.87 $\mu g/m^3$ (standard deviation = 335.27 $\mu g/m^3$) and 1,563.54 $\mu g/m^3$ (standard deviation = 915.12 $\mu g/m^3$) respectively. Mean indoor CO level in winter was found to be significantly higher than that of summer with a summer/winter ratio of 0.57 (standard deviation = 0.28) was observed.

4.10.3.4 The mean indoor CO levels of the 5 office premises for all surveys before and after holidays were 1,163.11 $\mu g/m^3$ (standard deviation = 449.07 $\mu g/m^3$) and 1,178.30 $\mu g/m^3$

PM3006517360

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

(standard deviation = 614.61 $\mu g/m^3$), respectively. There was no significant difference between mean indoor CO level before and after holidays with a before/after holiday ratio of 1.11 (standard deviation = 0.41) was observed.

4.10.4 Carbon Dioxide (CO_2)

4.10.4.1 The mean indoor CO_2 levels of the 5 office premises were found to be 874.82 ppm (standard deviation = 27.55 ppm) and 829.78 ppm (standard deviation = 50.43 ppm) for the summer survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was found to be 1.06 (standard deviation = 0.08).

4.10.4.2 The mean indoor CO_2 levels of the 5 office premises were 970.23 ppm (standard deviation = 92.22 ppm) and 957.44 ppm (standard deviation = 77.95 ppm) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 1.01 (standard deviation = 0.07).

4.10.4.3 The mean indoor CO_2 levels of the 5 office premises for all summer and winter surveys were 852.30 ppm (standard deviation = 26.15 ppm) and 963.84 ppm (standard deviation = 78.55 ppm), respectively. Mean indoor CO_2 level in winter was marginally higher than that of summer with a summer/winter ratio of 0.89 (standard deviation = 0.06) was observed.

4.10.4.4 The mean indoor CO_2 levels of the 5 office premises for all surveys before and after holidays were 922.53 ppm (standard deviation = 53.45 ppm) and 893.61 ppm (standard deviation = 55.88 ppm), respectively. There was no significant difference between mean indoor CO_2 level before and after holidays with a before/after holiday ratio of 1.03 (standard deviation = 0.05) was observed.

4.10.5 Nitrogen Dioxide (NO_2)

4.10.5.1 The mean indoor NO_2 levels of the 5 office premises were 16.55 $\mu g/m^3$ (standard deviation = 11.35 $\mu g/m^3$) and 22.32 $\mu g/m^3$ (standard deviation = 15.61 $\mu g/m^3$) for the summer survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 0.77 (standard deviation = 0.23).

4.10.5.2 The mean indoor NO_2 levels of the 5 office premises were 37.21 $\mu g/m^3$ (standard deviation = 27.54 $\mu g/m^3$) and 34.51 $\mu g/m^3$ (standard deviation = 20.47 $\mu g/m^3$) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 1.18 (standard deviation = 0.74).

4.10.5.3 The mean indoor NO_2 levels of the 5 office premises for all summer and winter surveys were 19.43 $\mu g/m^3$ (standard deviation = 13.38 $\mu g/m^3$) and 35.86 $\mu g/m^3$ (standard deviation = 21.46 $\mu g/m^3$), respectively. Mean indoor NO_2 level in winter was significantly higher than that of summer with a summer/winter ratio of 0.55 (standard deviation = 0.11) was observed.

4.10.5.4 The mean indoor NO_2 levels of the 5 office premises for all surveys before and after holidays were 26.88 $\mu g/m^3$ (standard deviation = 18.10 $\mu g/m^3$) and 28.42 $\mu g/m^3$ (standard deviation = 17.59 $\mu g/m^3$), respectively. There was no significant difference between mean

PM3006517361

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

indoor NO_2 level before and after holidays with a before/after holiday ratio of 096 (standard deviation = 0.42) was observed.

4.10.5.5 Formaldehyde (HCHO)

4.10.5.6 The mean indoor HCHO levels of the 5 office premises were 52.48 $\mu g/m^3$ (standard deviation = 37.50 $\mu g/m^3$) and 71.55 $\mu g/m^3$ (standard deviation = 51.20 $\mu g/m^3$) for the summer survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 0.76 (standard deviation = 0.12).

4.10.5.7 The mean indoor HCHO levels of the 5 office premises were found to be 132.20 $\mu g/m^3$ (standard deviation = 120.18 $\mu g/m^3$) and 145.34 $\mu g/m^3$ (standard deviation = 102.58 $\mu g/m^2$) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was found to be 0.83 (standard deviation = 0.29). The high standard deviations of the winter samples were due to one of the surveyed office premises (OFF-III) was affected by renovation in its neighbourhood.

4.10.5.8 The mean indoor HCHO levels of the 5 office premises for all summer and winter surveys were 62.02 $\mu g/m^3$ (standard deviation = 44.22 $\mu g/m^3$) and 138.77 $\mu g/m^3$ (standard deviation = 110.59 $\mu g/m^3$), respectively. Mean indoor HCHO level in winter was found to be significantly higher than that of summer with a summer/winter ratio of 0.63 (standard deviation = 0.44) was observed. If all HCHO results of OFF-III were taken out, the mean summer/ ratio was found to increase to 0.68 (standard deviation = 0.49).

4.10.5.9 The mean indoor HCHO levels of the 5 office premises for all surveys before and after holidays were 92.34 $\mu g/m^3$ (standard deviation = 69.62 $\mu g/m^3$) and 108.44 $\mu g/m^3$ (standard deviation = 67.58 $\mu g/m^3$) respectively. Mean indoor HCHO levels were found to be slightly higher after holidays with a before/after holiday ratio of 0.81 (standard deviation = 0.21) was observed.

4.10.6 Respirable Suspended Particulates (RSP)

4.10.6.1 The mean indoor RSP levels of the 5 office premises were found to be 25.48 $\mu g/m^3$ (standard deviation = 14.45 $\mu g/m^3$) and 28.42 $\mu g/m^3$ (standard deviation = 12.72 $\mu g/m^3$) for the summer survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 0.89 (standard deviation = 0.32).

4.10.6.2 The mean indoor RSP levels of the 5 office premises were 55.90 $\mu g/m^3$ (standard deviation = 54.03 $\mu g/m^3$) and 31.96 $\mu g/m^3$ (standard deviation = 19.56 $\mu g/m^3$) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was found to be 2.27 (standard deviation = 2.69).

4.10.6.3 The mean indoor RSP levels of the 5 office premises for all summer and winter surveys were 26.95 $\mu g/m^3$ (standard deviation = 13.15 $\mu g/m^3$) and 43.93 $\mu g/m^3$ (standard deviation = 27.31 $\mu g/m^3$) respectively. Mean indoor RSP level in winter was slightly higher than that of summer with a summer/winter ratio of 0.76 (standard deviation = 0.40) was observed.

4.10.6.4 The mean indoor RSP levels of the 5 office premises for all surveys before and after holidays were 40.69 $\mu g/m^3$ (standard deviation = 27.01 $\mu g/m^3$) and 30.19 $\mu g/m^3$ (standard deviation = 15.27 $\mu g/m^3$), respectively. Mean indoor RSP levels were found to be slightly

PM3006517362

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

higher before holidays with a before/after holiday ratio of 1.62 (standard deviation = 1.57) was observed.

4.10.7 Ozone (O_3)

4.10.7.1 The mean indoor O_3 levels of the 5 office premises were found to be 32.50 $\mu g/m^3$ (standard deviation = 11.22 $\mu g/m^3$) and 32.27 $\mu g/m^3$ (standard deviation = 5.58 $\mu g/m^3$) for the summer survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 1.01 (standard deviation = 0.26).

4.10.7.2 The mean indoor O_3 levels of the 5 office premises were found to be 28.62 $\mu g/m^3$ (standard deviation = 2.54 $\mu g/m^3$) and 39.86 $\mu g/m^3$ (standard deviation = 19.27 $\mu g/m^3$) for the winter survey before and after a weekend/ public holiday, respectively. The ratio between the mean of before and after holiday was 0.82 (standard deviation = 0.27).

4.10.7.3 The mean indoor O_3 levels of the 5 office premises for all summer and winter surveys were 32.39 $\mu g/m^3$ (standard deviation = 7.36 $\mu g/m^3$) and 34.24 $\mu g/m^3$ (standard deviation = 9.92 $\mu g/m^3$), respectively. There was no significant difference between mean indoor O_3 level in summer and winter with a summer/winter ratio of 1.03 (standard deviation = 0.43).

4.10.7.4 The mean indoor O_3 levels of the 5 office premises for all surveys before and after holidays were 30.56 $\mu g/m^3$ (standard deviation = 5.44 $\mu g/m^3$) and 36.07 $\mu g/m^3$ (standard deviation = 7.98 $\mu g/m^3$) respectively. There was no significant difference between mean indoor O_3 levels before and after holidays with a before/after holiday ratio of 0.88 (standard deviation = 0.25).

4.10.8 Nicotine

4.10.8.1 The mean indoor nicotine levels of the 5 office premises for all summer and winter surveys were below detection limit (<0.95 $\mu g/m^3$) (standard deviation = 0.00 $\mu g/m^3$) and 1.24 $\mu g/m^3$ (standard deviation = 0.50 $\mu g/m^3$), respectively. The summer/winter ratio was found to be 0.84 (standard deviation = 0.27).

4.10.8.2 The mean indoor nicotine levels of the 5 office premises for all surveys before and after holidays were 1.10 $\mu g/m^3$ (standard deviation = 0.30 $\mu g/m^3$) and 1.01 $\mu g/m^3$ (standard deviation = 0.13 $\mu g/m^3$) respectively. There was no significant difference between mean indoor nicotine levels before and after holidays with a before/after holiday ratio of 1.10 (standard deviation = 0.17).

4.10.9 Benzene

4.10.9.1 The mean indoor benzene levels of the 5 office premises were found to be 7.67 cfu/m^3 (standard deviation = 7.41 $\mu g/m^3$) and 7.41 $\mu g/m^3$ (standard deviation = 8.03 $\mu g/m^3$) for the summer survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 2.77 (standard deviation = 3.23).

4.10.9.2 The mean indoor benzene levels of the 5 office premises were found to be 66.13 $\mu g/m^3$ (standard deviation = 121.60 $\mu g/m^3$) and 12.51 $\mu g/m^3$ (standard deviation = 12.22 $\mu g/m^3$) for the winter survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 5.49 (standard deviation = 6.52).

PM3006517363

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.10.9.3 The mean indoor benzene levels of the 5 office premises for all summer and winter surveys were 7.54 $\mu g/m^3$ (standard deviation = 6.09 $\mu g/m^3$) and 39.32 $\mu g/m^3$ (standard deviation = 62.89 $\mu g/m^3$) respectively. The mean indoor benzene level was significantly higher in summer with a summer/winter ratio of 2.52 (standard deviation = 4.84).

4.10.9.4 The mean indoor benzene levels of the 5 office premises for all surveys before and after holidays were 36.90 $\mu g/m^3$ (standard deviation = 59.85 $\mu g/m^3$) and 9.96 $\mu g/m^3$ (standard deviation = 6.58 $\mu g/m^3$) respectively. The mean indoor benzene level was found to be significantly higher before holidays with a before/after holiday ratio of 2.89 (standard deviation = 2.92).

4.10.10 Toluene

4.10.10.1 The mean indoor toluene levels of the 5 office premises were found to be 364.99 $\mu g/m^3$ (standard deviation = 618.49 $\mu g/m^3$) and 529.55 $\mu g/m^3$ (standard deviation = 1,009.82 $\mu g/m^3$) for the summer survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 3.56 (standard deviation = 4.38).

4.10.10.2 The mean indoor toluene levels of the 5 office premises were 3,658.63 $\mu g/m^3$ (standard deviation = 7,464.85 $\mu g/m^3$) and 2,923.03 $\mu g/m^3$ (standard deviation = 4,554.00 $\mu g/m^3$) for the winter survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 0.78 (standard deviation = 0.50).

4.10.10.3 The mean indoor toluene levels of the 5 office premises for all summer and winter surveys were 447.27 $\mu g/m^3$ (standard deviation = 813.41 $\mu g/m^3$) and 3,290.83 $\mu g/m^3$ (standard deviation = 5,987.38 $\mu g/m^3$) respectively. The mean indoor toluene level was significantly higher in winter with a summer/winter ratio of 0.47 (standard deviation = 0.56).

4.10.10.4 The mean indoor toluene levels of the 5 office premises for all surveys before and after holidays were 2,011.81 µg/m3 (standard deviation = 3,688.22 µg/m3) and 1,726.29 µg/m3 (standard deviation = 2,355.04 µg/m3) respectively. There was no significant difference between mean indoor toluene level before and after holidays with a before/after holiday ratio of 1.06 (standard deviation = 0.58).

4.10.11 Airborne Fungi

4.10.11.1 The mean indoor airborne fungi levels of the 5 office premises were 86.33 cfu/m^3 (standard deviation = 43.84 cfu/m^3) and 132.70 cfu/m^3 (standard deviation = 93.96 cfu/m^3) for the summer survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 0.93 (standard deviation = 0.81).

4.10.11.2 The mean indoor airborne fungi levels of the 5 office premises were 179.97 cfu/m^3 (standard deviation = 144.40 cfu/m^3) and 80.40 cfu/m^3 (standard deviation = 103.61 cfu/m^3) for the winter survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 3.95 (standard deviation = 2.61).

4.10.11.3 The mean indoor airborne fungi levels of the 5 office premises for all summer and winter surveys were 109.52 cfu/m^3 (standard deviation = 53.29 cfu/m^3) and 130.18 cfu/m^3 (standard deviation = 123.39 cfu/m^3), respectively. The mean indoor airborne fungi level was found to be slightly higher in summer than winter with a summer/winter ratio of 1.16 (standard deviation = 0.79).

PM3006517364

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.10.11.4 The mean indoor airborne fungi levels of the 5 office premises for all surveys before and after holidays were 133.15 cfu/m^3 (standard deviation = 88.52 cfu/m^3) and 106.55 cfu/m^3 (standard deviation = 73.06 cfu/m^3) respectively. The mean indoor airborne fungi level was found to be slightly higher before and after holidays with a before/after holiday ratio of 1.44 (standard deviation = 0.70).

4.10.12 Airborne Bacteria

4.10.12.1 The mean indoor airborne bacteria levels of the 5 office premises were 946.30 cfu/m^3 (standard deviation = 1,030.10 cfu/m^3) and 1,147.50 cfu/m^3 (standard deviation = 637.24 cfu/m^3) for the summer survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 1.03 (standard deviation = 0.84).

4.10.12.2 The mean indoor airborne bacteria levels of the 5 office premises were 437.73 cfu/m^3 (standard deviation = 295.17 cfu/m^3) and 421.17 cfu/m^3 (standard deviation = 235.60 cfu/m^3) for the winter survey before and after a weekend/ public holiday respectively. The ratio between the mean of before and after holiday was 1.30 (standard deviation = 1.04).

4.10.12.3 The mean indoor airborne bacteria levels of the 5 office premises for all summer and winter surveys were 1,046.90 cfu/m^3 (standard deviation = 638.37 cfu/m^3) and 429.45 cfu/m^3 (standard deviation = 188.31 cfu/m^3) respectively. The mean indoor airborne fungi level was significantly higher in summer than winter with a summer/winter ratio of 4.28 (standard deviation = 5.97).

4.10.12.4 The mean indoor airborne bacteria levels of the 5 office premises for all surveys before and after holidays were 692.02 cfu/m^3 (standard deviation = 439.97 cfu/m^3) and 784.33 cfu/m^3 (standard deviation = 311.65 cfu/m^3), respectively. There was no significant difference between mean indoor airborne bacteria level before and after holidays with a before/after holiday ratio of 0.98 (standard deviation = 0.64).

4.10.13 Dustmite Allergen

4.10.13.1 The mean indoor dustmite allergen levels of the 5 office premises for all summer and winter surveys were 5.03 µg/g dust (standard deviation = 4.31 µg/g dust) and 15.42 µg/g dust (standard deviation = 21.99 µg/g dust) respectively.

4.10.13.2 The mean indoor dustmite allergen levels of the 5 office premises for all surveys before and after holidays were 8.35 µg/g dust (standard deviation = 13.56 µg/g dust) and 4.98 µg/g dust (standard deviation = 6.09 µg/g dust), respectively. The mean indoor dust mite allergen level was significantly higher before holidays with a before/after holiday ratio of 3.08 (standard deviation = 4.41) was observed.

4.11 Results of the Public Place Surveys

4.11.1 Temperature

4.11.1.1 The average temperature recorded at the surveyed of the following public places are summarised as follows:

PM3006517365

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

	Cinemas	Restaurants	Shopping Malls
Average temperature (range)	21.2 to 25.0 °C	18.8 to 27.2 °C	21.9 to 25.5 °C
Mean temperature	23.4 °C	23.6 °C	23.5 °C,
Standard deviation	1.55	2.39	1.17

4.11.1.2 The average outdoor temperature recorded at the fresh air intake position of the 8 shopping malls ranged from 21.6 to 29.8 °C (mean = 26.7 °C, standard deviation = 2.5).

4.11.2 *Relative Humidity (RH)*

	Cinemas	Restaurants	Shopping Malls
Average RH (range)	53.50 to 60.00 %	52.14 to 73.30%	55.74 to 67.28%
Mean RH	57.09 %	62.58%	61.20%,
Standard deviation	2.5	5.92	4.0

4.11.2.1 The average outdoor relative humidity recorded at the fresh air intake position of the 8 shopping malls ranged from 58.0 to 83.1 % (mean = 72.9 %, standard deviation = 8.0).

4.11.3 Carbon Monoxide (CO)

4.11.3.1 The 3 highest CO levels were recorded at restaurant RES-X, RES-XVI and RES-XIX and they were pubs. This is likely to be due to heavy smoking inside these premises. The 4 restaurants with combustion source in the dining area had CO levels ranged from 2,235 to 4,441 μg/m3 (mean = 3,009 $\mu g/m^3$).

4.11.3.2 The average CO level at the surveyed cinemas ranged from 939 to 3,488 $\mu g/m^3$. CO is not envisaged to be a major problem for cinemas as smoking has been completed banned by law in all area of a cinema.

	Cinemas	Restaurants	Shopping Malls
Average CO (range)	939 to 3,488 $\mu g/m^3$	905 to 6,739 $\mu g/m^3$	767 to 3,181 $\mu g/m^3$
Mean CO	1,696 $\mu g/m^3$	3,344.9 $\mu g/m^3$	1,660 $\mu g/m^3$
Standard deviation	1,032.1	1,648	836.8

4.11.3.3 All the recorded CO levels at the surveyed public places were below the IAQ-O and the Hong Kong air quality objective (HKAQO) of 30,000 $\mu g/m^3$ (1-hr average) and 10,000 $\mu g/m^3$ (8-hr average).

4.11.4 *Carbon Dioxide (CO_2)*

4.11.4.1 The average CO_2 level at the surveyed restaurants ranged from 754 to 1,922. Figure 4-7 shows that 80% of the restaurants (16 out of 20) had average CO_2 level above the IAQ-O of 1,000 ppm which indicates insufficient fresh air supply.

4.11.4.2 The average CO_2 levels at the cinema surveyed was found to range from 546 to 2,369 ppm with 60% of them (3 out of 5) had average CO_2 level above the IAQ-O of 1,000 ppm.

4.11.4.3 The average CO_2 level at the surveyed shopping malls ranged from 716 to 1,371 ppm. Three out of eight (an equivalent of 37.5%) had an average CO_2 level above the IAQ-O of 1,000 ppm which indicates insufficient fresh air supply.

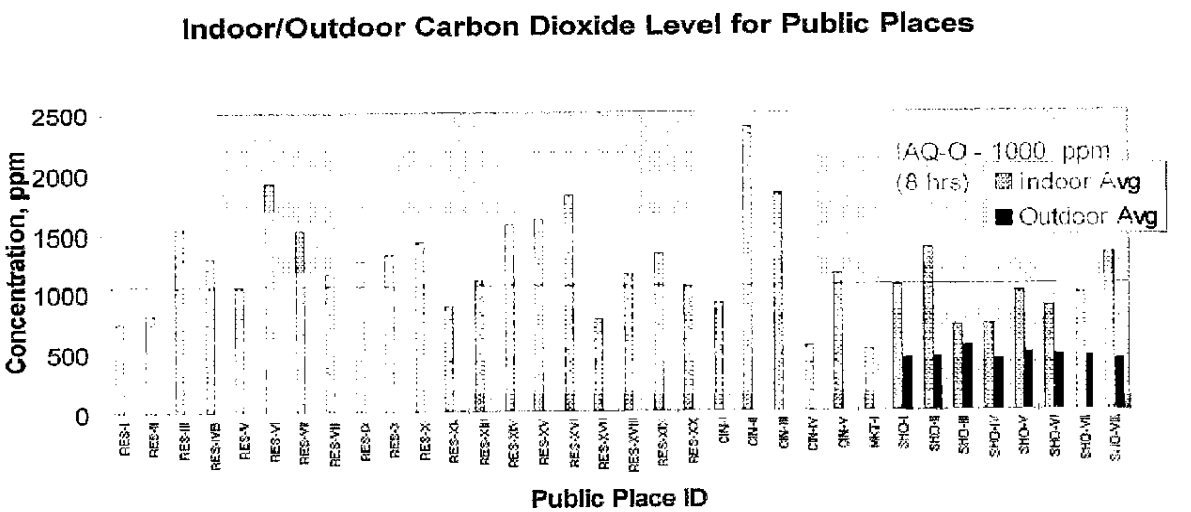
	Cinemas	Restaurants	Shopping Malls

PM3006517366

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Average CO_2 (range)	546 to 2,369 ppm	754 to 1,922 ppm	716 to 1,371 ppm
Mean CO_2	1,362 ppm	1,271.6 ppm	1,003 ppm
Standard deviation	731.4	331.9	244.1

Figure 4-7 Level of Carbon Dioxide in Public Places



Nitrogen Dioxide (NO_2)

4.11.4.4 In the restaurants surveyed, the average NO_2 level ranged from 30 to 279 $\mu g/m^3$. Higher NO_2 levels were recorded at 4 of the restaurants with direct source of combustion in the dining area with mean level of 199 $\mu g/m^3$.

4.11.4.5 The average NO_2 level for the cinema surveyed ranged from 23 to 134 $\mu g/m^3$.

4.11.4.6 The average NO_2 level at the shopping malls was found to range from 38 to 98 $\mu g/m^3$.

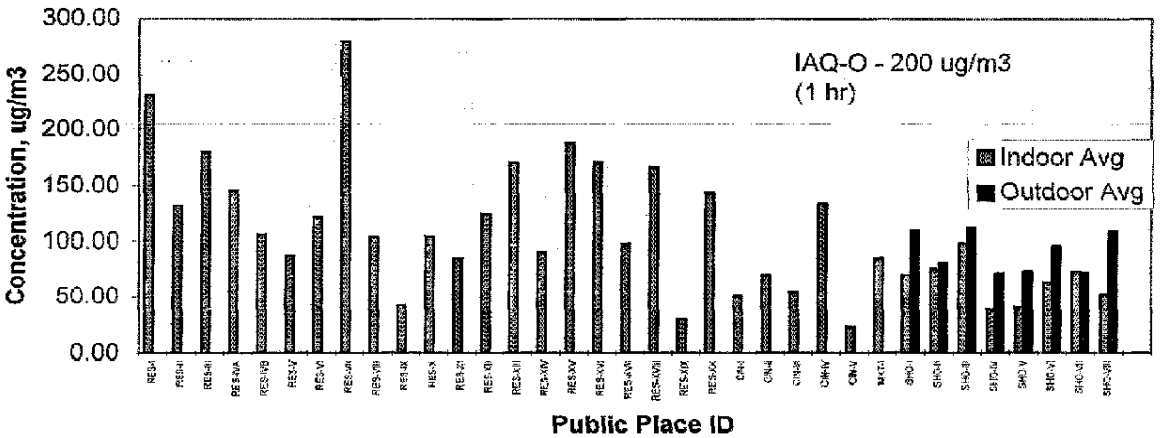
	Cinemas	Restaurants	Shopping Malls
Average NO_2 (range)	23 to 134 $\mu g/m^3$	30 to 279 $\mu g/m^3$	38 to 98 $\mu g/m^3$
Mean NO_2	66.1 $\mu g/m^3$	133 $\mu g/m^3$	64 $\mu g/m^3$
Standard deviation	41.58	60.5	20.0

4.11.4.7 Out of the NO_2 samples obtained from the surveyed public places, 2 of them had mean NO_2 level above the IAQ-O of 200 $\mu g/m^3$ (1-hr average) which included one of the Korean barbecue restaurant and the Chinese hot pot restaurant (see Figure 4-8).

Figure 4-8 Level of NO_2 in Public Places

PM3006517367
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Indoor/Outdoor Nitrogen Dioxide Level for Public Places



Respirable Suspended Particulates (RSP)

4.11.4.8 The average RSP level at the surveyed restaurants ranged from 53 to 1,070 $\mu g/m^3$. Higher RSP levels were recorded at the 3 pubs mentioned above (mean = 761 $\mu g/m^3$) which was likely due to heavy smoking inside these venues.

4.11.4.9 The average RSP level in the cinema surveyed ranged from 43 to 65 $\mu g/m^3$.

4.11.4.10 The average RSP level at the surveyed shopping malls ranged from 38 to 111 $\mu g/m^3$.

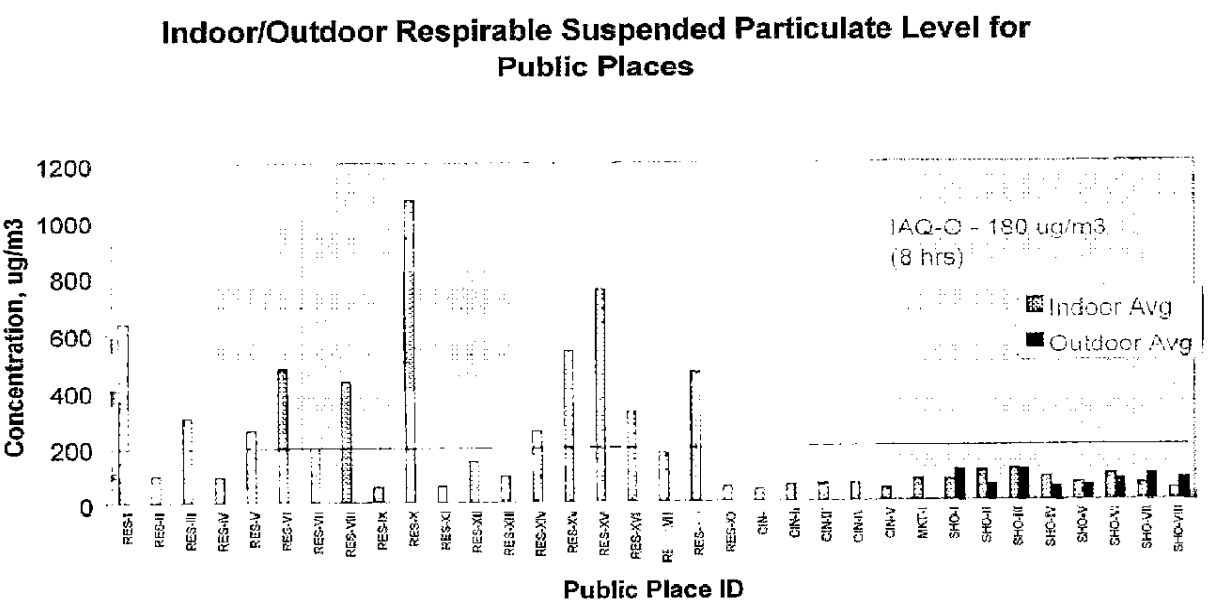
	Cinemas	Restaurants	Shopping Malls
Average RSP (range)	43 to 65 $\mu g/m^3$	53 to 1,070 $\mu g/m^3$	38 to 111 $\mu g/m^3$
Mean RSP	55 $\mu g/m^3$	323 $\mu g/m^3$	78 $\mu g/m^3$
Standard deviation	10.56	270.2	24.58

4.11.4.11 Out of the RSP samples obtained from the surveyed public places, 60% of the restaurants (12 out of 20) had mean RSP level above the IAQ-O of 180 $\mu g/m^3$ (1-hr average) which included all 3 pubs, 4 of the 5 Chinese dim sum lunch, all 2 Korean barbecue restaurant, the Mongolian barbecue restaurant, the Chinese hot pot restaurant, and the Indian/Thai restaurant (see Figure 4-9).

PM3006517368

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Figure 4-9 Level of RSP in Public Places



4.11.5 Ozone (O_3)

4.11.5.1 O_3 was only detected at 3 of the surveyed restaurants with levels of 64.6, 161.2 and 367.3 $\mu g/m^3$ were recorded during a Japanese dinner, a Korean barbecue dinner and a Chinese dim sum lunch, respectively. No valid O_3 samples were obtained from restaurants RES-V.

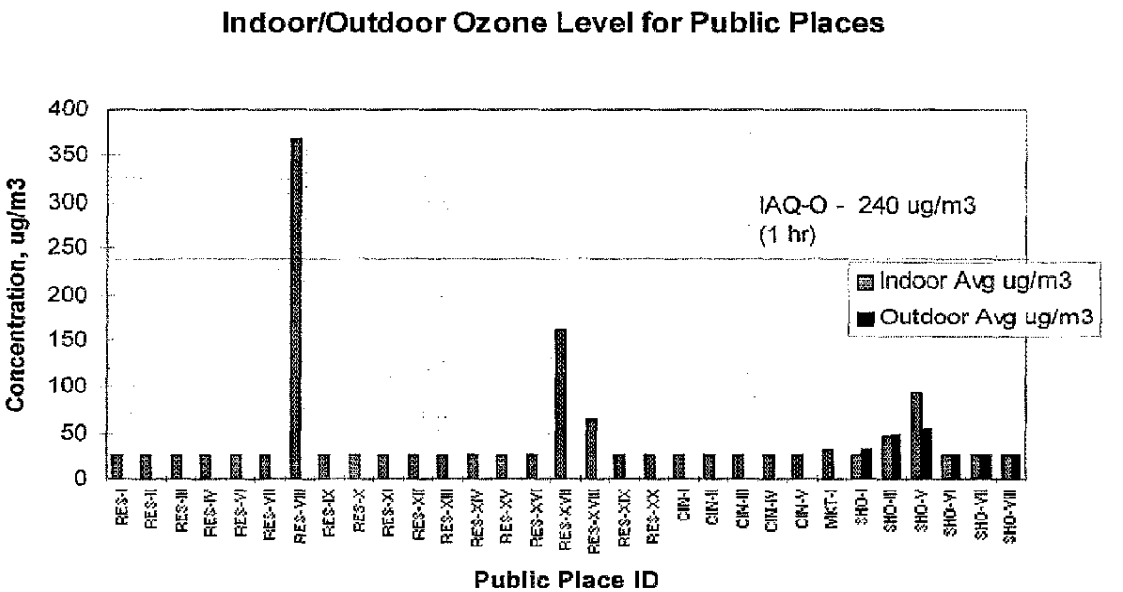
4.11.5.2 All the O_3 samples obtained from the surveyed cinemas were below the detected limit of 27.5 $\mu g/m^3$.

4.11.5.3 O_3 was only detected at 1 of the surveyed shopping mall with the average levels of 93.3 $\mu g/m^3$ were recorded at SHO-III and SHO-V, respectively. No valid O_3 samples were obtained from shopping malls SHO-II and SHO-IV.

4.11.5.4 All except one of the O_3 samples obtained from the surveyed public places were below the 1-hour IAQ-O of 240 $\mu g/m^3$. O_3 level at the 2 restaurants exceeded the 8-hour average IAQ-O of 120 $\mu g/m^3$ but no source O_3 emission was not identified during the survey (see Figure 4-10).

PM3006517369
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Figure 4-10 Level of Ozone in Public Places



Formaldehyde (HCHO)

4.11.5.5 The highest HCHO level at the restaurants surveyed was during the Chinese banquet dinner at a newly renovated restaurant inside a hotel with high density of partitioning. No valid HCHO samples were obtained from restaurant RES-XVIII.

4.11.5.6 HCHO level at the cinemas surveyed ranged from <20.86 to 463.95 $\mu g/m^3$. The high mean level was due to an exceptional high value of 463.95 $\mu g/m^3$ recorded from one of the cinemas.

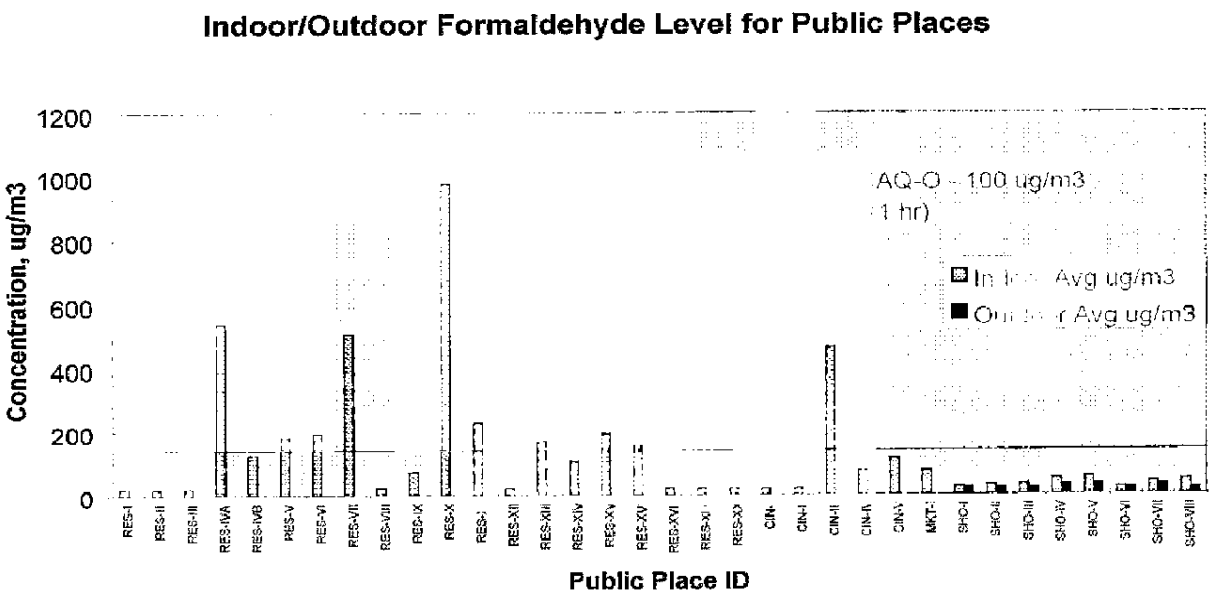
4.11.5.7 HCHO level at the shopping malls surveyed ranged from 23.98 to 57.15 $\mu g/m^3$.

	Cinemas	Restaurants	Shopping Malls
Average HCHO (range)	<20.86 to 463.95 $\mu g/m^3$	<20.86 to 975.18 $\mu g/m^3$	23.98 to 57.15 $\mu g/m^3$
Mean HCHO	139.36 $\mu g/m^3$	161.73 $\mu g/m^3$	38.84 $\mu g/m^3$
Standard deviation	185.68	230.83	12.63

4.11.5.8 Out of the samples obtained from the surveyed public places, 47% of the restaurants (10 out of 19) and 40% of cinemas (2 out of 5) had mean HCHO level above the standard IAQ-O of 100 $\mu g/m^3$ (1-hr average). None of the shopping malls surveyed had average HCHO level above the 1-hr average of the standard IAQ-O. 11 of the restaurants and 3 of the cinemas exceeded the 8-hour IAQ-O of 50 $\mu g/m^3$ (see Figure 4-11).

PM3006517370
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Figure 4-11 Level of HCHO in Public Places



4.11.6 *Nicotine*

4.11.6.1 Nicotine levels recorded at the surveyed restaurants ranged from below detection limit (<0.95) to 56 μg/m^3. Only 53% of the restaurants surveyed (i.e., 10 out of 19) had nicotine detected in the indoor air, two of the pubs with the highest nicotine recorded (23 and 56 μg/m^3) were found to be about 4 to 9 fold higher than the average of the remaining 7 restaurants with nicotine detected. No valid nicotine samples were obtained from restaurant RES-XI.

4.11.6.2 All the nicotine samples obtained from the surveyed cinemas (CIN-I, IV and V) were found to be below the detection limit of 0.95 μg/m^3 which was due to the ban of smoking in cinemas.

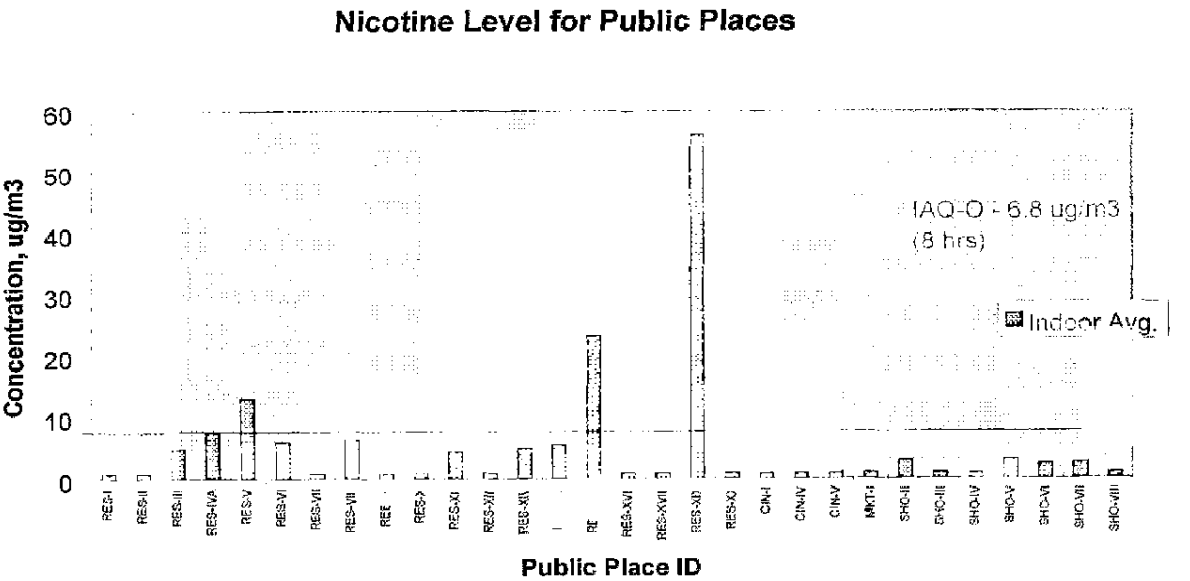
4.11.6.3 Nicotine level at the surveyed shopping malls ranged from <0.95 to 3.2 μg/m^3. No valid nicotine samples were obtained from shopping mall SHO-I.

	Cinemas	Restaurants	Shopping Malls
Average nicotine (range)	below detection limits	<0.95 to 56 μg/m^3	<0.95 to 3.2 μg/m^3
Mean nicotine		7.4 μg/m^3	2 μg/m^3
Standard deviation		13.06	0.98

4.11.6.4 Out of the nicotine samples obtained from the surveyed public places, 21% of the restaurants (4 out of 19) had nicotine level above the IAQ-O of 6.8 μg/m^3 (8-hr average) which included 2 pubs, 1 western fast food, and 1 of the Chinese dim sum restaurant (see Figure 4-12).

PM3006517371
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Figure 4-12 Level of Nicotine in Public Places



4.11.7 Volatile Organic Compounds (VOCs)

4.11.7.1 All the Benzene levels recorded were below the IAQ-O of 16.1 $\mu g/m^3$ (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average Benzene (range)	<0.32 to 2.87 $\mu g/m^3$	<0.32 to 31.9 $\mu g/m^3$	2.08 to 10.21 $\mu g/m^3$
Mean Benzene	1.85 $\mu g/m^3$	12.23 $\mu g/m^3$	5.78 $\mu g/m^3$
Standard deviation	1.04	8.85	2.70

4.11.7.2 All except two of the Carbon tetrachloride levels recorded in the restaurants surveyed were found to be below detection limit (<0.63 $\mu g/m^3$). All the recorded levels in these public places were below the IAQ-O of 103 $\mu g/m^3$ (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average Carbon tetrachloride	<0.63 to 2.52 $\mu g/m^3$	<0.63 to 1.26 $\mu g/m^3$	<0.63 to 0.79 $\mu g/m^3$
Mean Carbon tetrachloride	1.26 $\mu g/m^3$	0.69 $\mu g/m^3$	0.65 $\mu g/m^3$
Standard deviation	0.89	0.19	0.06

4.11.7.3 Chloroform levels recorded from the public places surveyed were below the IAQ-O of 163 $\mu g/m^3$ (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average Chloroform (range)	<0.21 to 1.24 $\mu g/m^3$	<0.21 to 10.74 $\mu g/m^3$	<0.21 to 0.83 $\mu g/m^3$
Mean Chloroform	0.66 $\mu g/m^3$,	1.86 $\mu g/m^3$	0.47 $\mu g/m^3$
Standard deviation	0.47	2.36	0.24

PM3006517372
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.11.7.4 o-Dichlorobenzene levels recorded from the surveyed public places were found to range from below detection limit (<0.60) to 6.61 μg/m^3 (mean = 1.26 μg/m^3, standard deviation = 1.53 μg/m^3) for restaurants; from <0.60 to 6.61 μg/m^3 (mean = 2.04 μg/m^3, standard deviation = 2.57 μg/m^3) for cinemas; and from <0.60 to 5.56 μg/m^3 (mean = 1.69 μg/m^3, standard deviation = 1.74 μg/m^3) for shopping malls. All the recorded levels were below the IAQ-O of 1,830 μg/m^3 (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average o-Dichlorobenzene	<0.60 to 6.61 μg/m^3	<0.60 to 6.61 μg/m^3	<0.60 to 5.56 μg/m^3
Mean o-Dichlorobenzene	2.04 μg/m^3	1.26 μg/m^3	1.69 μg/m^3
Standard deviation	2.57	1.53	1.74

4.11.7.5 m-Dichlorobenzene levels recorded from the surveyed public places were found to range from below detection limit (<0.60) to 3.61 μg/m^3 (mean = 0.87 μg/m^3, standard deviation = 0.77 μg/m^3) for restaurants; from <0.60 to 6.01 μg/m^3 (mean = 1.80 μg/m^3, standard deviation = 2.37 μg/m^3) for cinemas; and from <0.60 to 3.31 μg/m^3 (mean = 1.54 μg/m^3, standard deviation = 1.06 μg/m^3) for shopping malls. All the recorded levels were below the IAQ-O of 1,830 μg/m^3 (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average m-Dichlorobenzene	<0.60 to 6.01 μg/m^3	<0.60 to 3.61 μg/m^3	<0.60 to 3.31 μg/m^3
Mean m-Dichlorobenzene	1.80 μg/m^3	0.87 μg/m^3	1.54 μg/m^3
Standard deviation	2.37	0.77	1.06

4.11.7.6 p-Dichlorobenzene levels recorded from the surveyed public places were found to range from 1.80 to 37.88 μg/m^3 (mean = 11.60 μg/m^3, standard deviation = 8.14 μg/m^3) for restaurants; from 1.80 to 42.09 μg/m^3 (mean = 12.14 μg/m^3, standard deviation = 16.90 μg/m^3) for cinemas; and from 1.65 to 36.98 μg/m^3 (mean = 13.88 μg/m^3, standard deviation = 12.45 μg/m^3) for shopping malls. All the recorded levels were below the IAQ-O of 1,100 μg/m^3 (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average p-Dichlorobenzene	1.80 to 42.09μg/m^3	1.80 to 37.88 μg/m^3	1.65 to 36.98 μg/m^3
Mean p-Dichlorobenzene	12.14 μg/m^3	11.60 μg/m^3	13.88 μg/m^3
Standard deviation	16.90	8.14	12.45

4.11.7.7 Ethylbenzene levels recorded from the surveyed public places were found to range from below detection limit (<0.43 μg/m^3) to 29.05 μg/m^3 (mean = 7.74 μg/m^3, standard deviation = 7.97 μg/m^3) for restaurants; from 1.3 to 11.27 μg/m^3 (mean = 3.81 μg/m^3, standard deviation = 4.2 μg/m^3) for cinemas; and from 1.19 to 20.48 μg/m^3 (mean = 8.29 μg/m^3, standard deviation = 6.3 μg/m^3) for shopping malls. All the recorded levels were below the IAQ-O of 10,000 μg/m^3 (8-hour average).

	Cinemas	Restaurants	Shopping Malls

PM3006517373

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Average Ethylbenzene	1.3 to 11.27 μg/m^3	<0.43 to 29.05 μg/m^3	1.19 to 20.48 μg/m^3
Mean Ethylbenzene	3.81 μg/m^3	7.74 μg/m^3	8.29 μg/m^3
Standard deviation	4.20	7.97	6.3

4.11.7.8 All Tetrachloroethylene levels recorded from the public places surveyed were below the IAQ-O of 250 μg/m^3 (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average Tetrachloroethylene	<0.68 to 5.43 μg/m^3	<0.68 to 31.23 μg/m^3	<0.68 to 7.47 μg/m^3
Mean Tetrachloroethylene	1.63 μg/m^3	5.6 μg/m^3	1.89 μg/m^3
Standard deviation	2.12	7.90	2.37

4.11.7.9 All the recorded Toluene levels in the premises surveyed as shown below were below the IAQ-O of 1,092 μg/m^3 (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average Toluene	6.02 to 8.65 μg/m^3	4.14 to 451.53 μg/m^3	9.79 to 232.35 μg/m^3
Mean Toluene	7.6 μg/m^3	104.08 μg/m^3	85.88 μg/m^3
Standard deviation	1.04	136.68	67.80

4.11.7.10 Trichloroethylene levels recorded from the public places surveyed were found to be below the IAQ-O of 770 μg/m^3 (8-hour average).

	Cinemas	Restaurants	Shopping Malls
Average Trichloroethylene	<0.54 to 1.08 μg/m^3	<0.54 to 3.23 μg/m^3	<0.54 to 13.85 μg/m^3
Mean	0.65 μg/m^3	1.02 μg/m^3	2.74 μg/m^3
Standard deviation	0.24	0.80	4.64

4.11.7.11 The levels of o-Xylene recorded in the survey of public places were as follows:

	Cinemas	Restaurants	Shopping Malls
Average o-Xylene	<0.43 to 25.58 μg/m^3	<0.43 to 41.62 μg/m^3	1.63 to 16.69 μg/m^3
Mean o-Xylene	6.42 μg/m^3	8.63 μg/m^3	7.55 μg/m^3
Standard deviation	10.74	9.32	4.68

4.11.7.12 All the recorded m,p-Xylene levels were below the IAQ-O of 4,850 μg/m^3 (8-hour average) as shown as follows:

	Cinemas	Restaurants	Shopping Malls
Average m,p-Xylene	1.73 to 69.37 μg/m^3	2.6 to 82.37 μg/m^3	3.25 to 54.09 μg/m^3
Mean m,p-Xylene	17.86 μg/m^3	22.85 μg/m^3	18.75 μg/m^3
Standard deviation	28.86	21.69	15.61

4.11.8 Fungi

PM3006517374

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

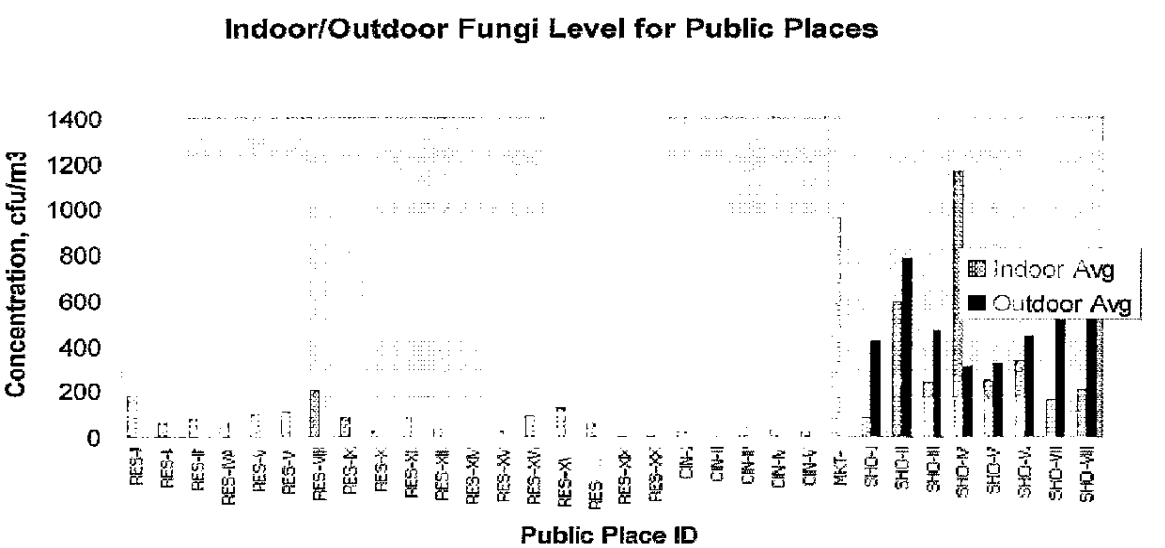
4.11.8.1 The average fungi level at the restaurants surveyed ranged from 6 to 200 cfu/m^3. No valid fungi samples were obtained from restaurants RES-VII and RES-XI.

4.11.8.2 Only one of the surveyed shopping malls with the highest average fungi level recorded (SHO-IV) had indoor/ outdoor fungi ratio greater than 1 which suggested possible presence of an amplifier in the indoor environment.

	Cinemas	Restaurants	Shopping Malls	Wet Market
Average fungi level (range)	6 to 44 cfu/m^3	6 to 200 cfu/m^3	77 to 1,161 cfu/m^3	794 to 1,147 cfu/m^3
Mean fungi level	26.2 cfu/m^3	77.11 cfu/m^3	376.54 cfu/m^3	959 cfu/m^3
Standard deviation	13.70	53.52	352.56	177.62

4.11.8.3 Out of all the public places surveyed, only 2 of the 8 shopping malls (25%) had mean indoor fungi level above 500 cfu/m3. All the indoor airborne fungi levels recorded from the wet markets surveyed were above 500 cfu/m^3 (see Figure 4-13). No toxigenic/ pathogenic fungi species were identified from the airborne samples.

Figure 4-13 Level of Fungi in Public Places



4.11.9 *Bacteria*

4.11.9.1 No valid bacteria samples were observed in the restaurants RES-VII and RES-XI.

4.11.9.2 The mean indoor/ outdoor bacteria ratio for samples obtained from shopping malls was found to be 5.44.

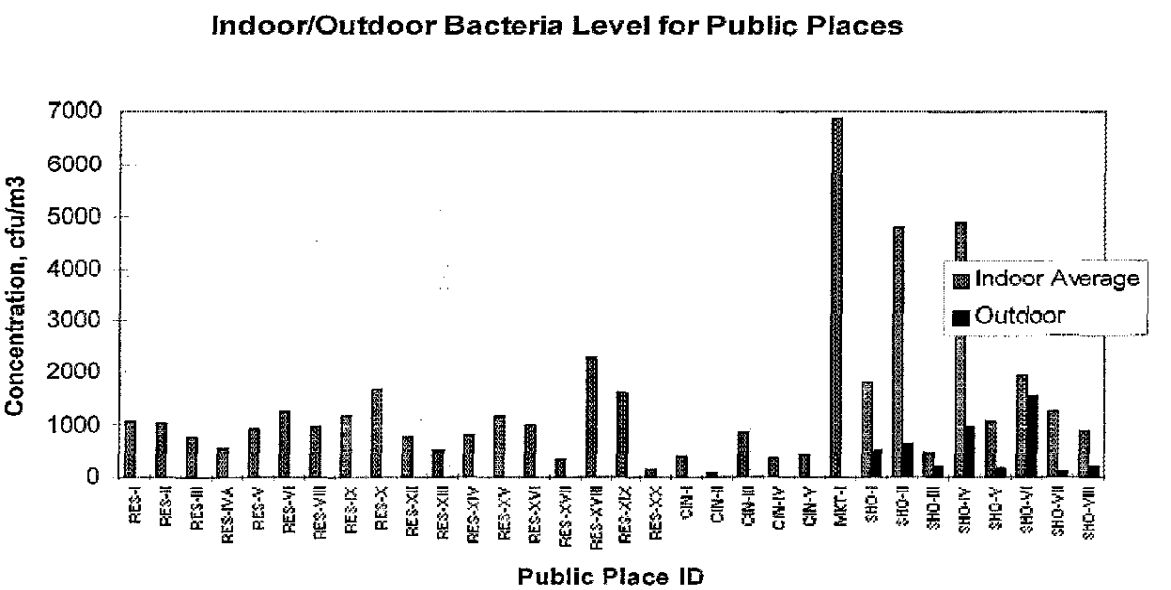
	Cinemas	Restaurants	Shopping Malls	Wet Market
Average bacteria	69 to 856	125 to 2,275	465 to 4,891	4,203 to

PM3006517375
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

level (range)	cfu/m^3	cfu/m^3	cfu/m^3	9,901 cfu/m^3
Mean bacteria level	430 cfu/m^3	1,003 cfu/m^3	2,140.1 cfu/m^3	6,876 cfu/m^3
Standard deviation	280.40 cfu/m^3	507.88	1,736	2,865

4.11.9.3 From the surveyed public places, 16 of the 18 restaurants, 1 of the 5 cinemas, and 7 of the 8 shopping malls had mean indoor bacteria level above 500 cfu/m^3 (*Figure 4-14*). Indoor airborne bacteria level recorded from the wet markets surveyed were above 500 cfu/m^3.

Figure 4-14 Level of Bacteria in Public Places



4.11.10 *Endotoxin*

4.11.10.1 The airborne endotoxin levels of the 8 shopping malls were all below the detection limit of 0.12 ng/m^3. Hence none of the sample was above the International Commission of Occupational Health (ICOH) guideline of 10 ng/m^3 for toxic penumonitis and airways inflammation.

4.11.11 *Glucan*

4.11.11.1 The airborne glucan levels of the 8 shopping malls were found to range from 1.19 to 4.47 ng/m^3 which were below the provisional guideline of 10 ng/m^3 (mean = 2.12 ng/m^3, standard deviation = 1.24 ng/m^3).

4.11.12 Dust Mite Allergen

4.11.12.1 Dust mite allergen from the dust samples of 3 shopping malls was found to range from below detection limit to 0.44 µg/g dust (mean = 0.19 µg/g dust, standard deviation = 0.23

PM3006517376
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

μg/g dust). All the samples had dust mite allergens level below 2 μg Der l/g dust which is considered "low" and not sufficient to cause allergic symptoms.

4.12 Results of the Mass Transit Railway (MTR) Surveys

4.12.1 Platform and Concourse

4.12.1.1 The average indoor temperature of the surveyed MTR platforms and concourses were found to be 25.95 and 28.11 °C, respectively. The average indoor relative humidity of the surveyed MTR platforms and concourses were 63.64 and 59.85%, respectively.

4.12.1.2 The average indoor air pollutant levels recorded from the 2 surveyed MTR platforms and concourses are summarised in Table 4-2.

Table 4-2 Average Indoor Air Pollutant Levels at MTR Platforms and Concourses

Pollutant	IAQ-O (1hr)	Measured Values	Platform	Concourse
CO (μg/m³)	30,000	Max	1,887	1,797
		Min	1,272	1,724
		Average	1,580	1,761
CO_2 (ppm)	*A*[b]	Max	1,045	1,295
		Min	940	1,121
		Average	992	1,208
HCHO (μg/m³)	100	Average	23	<21
NO_2 (μg/m³)	200	Average	23	77
O_3 (μg/m³)	240	Average	<27	<27
RSP (μg/m³)	180[b]	Average	106	126
Benzene (μg/m³)	16.1[b]	Average	3.03	4.63
Carbon tetrachloride (μg/m³)	103	Average	<0.63	3.47
Chloroform (μg/m³)	163	Average	<0.21	0.31
o-Dichlorobenzene (μg/m³)	1,830	Average	0.75	<0.6
m-Dichlorobenzene (μg/m³)	1,830	Average	<0.6	5.86
p-Dichlorobenzene (μg/m³)	1,100	Average	11.43	11.12
Ethylbenzene (μg/m³)	10,000	Average	5.96	7.15
Tetrachloroethylene (μg/m³)	250[b]	Average	4.24	12.73
Toluene (μg/m³)	1,092	Average	7.25	60.86
Trichloroethylene (μg/m³)	770[b]	Average	0.94	9.55
o-Xylene (μg/m³)	4,850	Average	9.00	8.67
m,p-Xylene (μg/m³)	4,850	Average	22.87	24.71
Airborne Fungi (cfu/m³)	500	Max	97	154
		Min	6	104
		Average	52	128
Airborne Bacteria (cfu/m³)	*C*	Max	1,616	2,210
		Min	84	2,235
		Average	1,224	2,222

Note:

[b] = 8 hours IAQ-objective

A = Carbon dioxide levels in subway trains are in general higher than the 1,000 ppm as used in other public places. The values measured are comparable with the guidelines for subway in the USA (5,000 ppm - 8 hr).

C = Bacteria count is expected to be high in densely populated area and air conditioned locations. Such counts are not meant to be indicator of health risk but serve as screening tests for further investigation.

PM3006517377

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.12.1.3 Two each of MTR platforms and MTR concourses were surveyed and the results recorded as follows:

Indoor airborne fungi level	MTR platforms	MTR concourses
Range	6 to 97 cfu/m^3	104 to 154 cfu/m^3
Average	51.8 cfu/m^3	128 cfu/m^3
Mean indoor/ outdoor ratio	0.19	0.55

4.12.1.4 Toxigenic and pathogenic fungi species, *Aspergillus flavus* and *Aspergillus versicolor*, were identified in one of the MTR concourses.

4.12.1.5 The average indoor airborne bacteria levels were recorded from 2 MTR platforms and 2 concourses and the results were as follows:

Indoor airborne bacteria level	MTR platforms	MTR concourses
Range	83.5 to1,616 cfu/m^3	2,209.5 to 2,234.5 cfu/m^3
Average	1223.8 cfu/m^3	2,222 cfu/m^3
Mean indoor/ outdoor ratio	0.16	2.50

4.12.2 Train Compartments

4.12.2.1 The average indoor temperature and relative humidity of the MTR train compartments surveyed were as follows:

MTR train compartments	Indoor temperature	Indoor relative humidity	Peak indoor RH
Average	24.83 °C	60.36 %,	58.5 %
Standard deviation	1.37	8.09	9.76

4.12.2.2 The average indoor air pollutant levels recorded from the surveyed MTR train compartments are summarised in Table 4-3.

Table 4-3 Average Indoor Air Pollutant Level at MTR Train Compartment

Pollutant	IAQ-O (1 hr)	Measured Values	Peak	Off-Peak
CO (µg/m^3)	30,000	Max	2,857	1,746

PM3006517378

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

		Min	1,512	1,728
		Average	2,178	1,737
CO_2 (ppm)	A^b	Max	2,650	1,340
		Min	1,345	1,146
		Average	2,195	1,243
RSP ($\mu g/m^3$)	180^b	Max	186	174
		Min	72	59
		Average	105	103
HCHO ($\mu g/m^3$)	100	Average	n.m.	n.m.
NO_2 ($\mu g/m^3$)	200	Average	121	128
O_3 ($\mu g/m^3$)	240	Average	<27.48	<27.48
Benzene ($\mu g/m^3$)	16.1^b	Average	5.03	5.74
Carbon tetrachloride ($\mu g/m^3$)	103	Average	<0.63	<0.63
Chloroform ($\mu g/m^3$)	163	Average	<0.21	<0.21
o-Dichlorobenzene ($\mu g/m^3$)	1,830	Average	1.05	<0.6
m-Dichlorobenzene ($\mu g/m^3$)	1,830	Average	3.16	<0.6
p-Dichlorobenzene ($\mu g/m^3$)	1,100	Average	29.16	13.23
Ethylbenzene ($\mu g/m^3$)	10,000	Average	3.90	2.39
Tetrachloroethylene ($\mu g/m^3$)	250^b	Average	29.37	5.77
Toluene ($\mu g/m^3$)	1,092	Average	39.14	25.59
Trichloroethylene ($\mu g/m^3$)	770^b	Average	1.88	6.73
o-Xylene ($\mu g/m^3$)	4,850	Average	4.12	6.94
m,p-Xylene ($\mu g/m^3$)	4,850	Average	10.30	17.35
Airborne Fungi (cfu/m^3)	500	Max	294	62
		Min	69	31
		Average	145	47
Airborne Bacteria (cfu/m^3)	*C*	Max	1,563	1,019
		Min	694	706
		Average	1,172	863

Note:

n.m. = not measured

^{b} = 8 hours IAQ-objective

A = Carbon dioxide levels in subway trains are in general higher than the 1,000 ppm as used in other public places. The values measured are comparable with the guidelines for subway in the USA (5,000 ppm - 8 hr).

C = Bacteria count is expected to be high in densely populated area and air conditioned locations. Such counts are not meant to be indicator of health risk but serve as screening tests for further investigation.

4.12.2.3 The average indoor airborne bacteria levels recorded from the surveyed MTR train compartments were 1,172 and 862.5 cfu/m^3 for peak and off-peak period, respectively. They ranged from 694 to to 1,563 cfu/m^3 during peak period whereas in the off-peak period, the airborne bacteria levels ranged from 706 to 1,019 cfu/m^3.

4.12.2.4 The average indoor airborne fungi levels recorded from the surveyed MTR train compartments were 145.3 and 46.5 $cfu/m^3$for peak and off-peak period, respectively. During peak period, the levels ranged from 69 to 294 cfu/m^3 whereas in the off-peak period, airborne fungi levels was found to range from 31 to 62 cfu/m^3.

PM3006517379

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

4.12.2.5 No toxigenic and pathogenic fungi species were identified in the MTR train compartments.

4.13 Conclusion

4.13.1 The on-site survey of forty office buildings illustrated that 37.5% of the premises showed exceedance in CO2 levels, 32.5% showed exceedance in formaldehyde levels while the quantity of fresh air supply also did not achieve the ASHRAE Standards. In addition, the bacterial and fungal counts were high in a number of premises compared to IAQ guidelines and some showed evidence of toxigenic and pathogenic species.

4.13.2 RSP measured both indoor and outdoor revealed that the former was affected by the latter.

4.13.3 The longitudinal studies revealed that there was a definite increase in contaminant levels during the winter while no significant accumulation of contaminant was observed after weekends.

4.13.4 The pilot study on public places pointed to some indoor air quality problems in that 75% of restaurants, 37.5% of shopping malls and 60% of cinemas showed levels of carbon dioxide well above ASHRAE Standards. In restaurants where naked fire was used in the dining room for special cuisines, the level of NO_2 exceeded the 1-hr IAQ-objective of 200 $\mu g/m^3$. Mean nicotine levels was found to exceed OSHA guideline of 6.8 $\mu g/m^3$ in restaurants. For the MTRC indoor air quality, the main problems were high carbon dioxide levels exceeding 1,300 ppm in the concourse and close to 2,700 ppm in the trains. With high density of people travelling in the train, the bacteria counts were high.

4.13.5 Despite there are no IAQ standards/ guidelines established for underground transportation facilities, IAQ at the surveyed MTR concourses and platforms during normal operational conditions was found to be comparable even with the health/comfort-based IAQ objectives recommended in this Study for non-industrial and public place environment. Since the count for the number of toxigenic/ pathogenic fungi species identified in the concourse samples was low, it was considered to be insignificant to warrant special attention. For the MTR train compartments, the only indoor air contaminant that exceeded the comfort-based level under normal operational condition was CO_2, with an average level of 2,200 ppm, recorded during the peak-hour period. The relatively higher levels of CO_2 are expected due to the extremely crowded conditions during peak hours. However, these levels are comparable with 5,000 ppm in the guidelines for subway design in the USA[2], which is also adopted by the MTRC. The maximum duration of people exposed to the measured levels would be about 1-2 hours a day, hence effectively, the human exposure is limited.

---

1 Tittany, J. 1997. Indoor Air Quality Update, Cutter Information Corp. US. Vol.10. No. 3, March, 1997.

2 U.S. Department of Commerce, National Technical Information Service, Subway Environmental Design Handbook Volume I: Principles and Applications , second edition, Mar 76.

PM3006517380

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

5. ANALYTICAL STATISTICS

5.1 Introduction

This chapter presents the methodologies used to analyse, correlate and project the data obtained from the questionnaire surveys and the actual measured concentrations for offices. The objective of the analysis is to specifically identify which are the significant factors affecting indoor air quality and correlate to the occupants' perception as well as to determine the percentage of sick building through the projection. .

5.2 Methodology

5.2.1 Correlation analysis which aims to identify the relationship between pairs, or groups of variables to a specified confidence level. The same type of tests also serve to test the null-hypotheses that pairs/groups of variables have no linear relationship.

5.2.2 Regression analysis is an extension of correlation analysis. When significant correlation is identified with an important parameter, the variables are combined together to identify the model which can best quantify the variability of the relationship and hence provide a tool for the prediction of this important parameter based on these independent variables.

5.2.3 Projection is essential when a limited sample size was surveyed due to various constraints. By the use of projection, the inference can be applied to the general population and the degree of confidence specified.

5.2.4 *Spearman's Correlation Analysis*

5.2.4.1 Spearman's correlation analysis between information obtained from the Study was conducted which included the following:

(i) Indoor pollutant levels and comfort factors measured during the surveys in the different areas at the 40 office premises; and

(ii) Information obtained from the questionnaire survey at the 40 office premises.

5.2.4.2 The significance of correlation between the following groups of data was specifically focused upon as summarised in Table 5-1.

PM3006517381

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 5-1 Parameters specifically targeted at to identify correlation

Group I
Perception / Response of Occupants

* Building Symptom Index (BSI)
  - Dry, itching or irritated eyes
  - Runny noise, sinus
  - Sore or dry throat
  - Unusual tiredness (fatigue)
  - Headache
  - Dry or itching skin

* Perception of Indoor Air Quality (IAQP) (degree of satisfaction)

*Sick leave Frequency (Sick) (days sick in the last month)

Group II
Measured Analytics

Air change
Temperature
Relative Humidity
CO
CO_2
Formaldehyde
NO_2
Ozone
RSP
Nicotine
VOCs
Bacteria
Fungi

Group III
Physical Parameters on Premises

District
HVAC
Office class
Building age
Floor level of study area
Exterior construction (formwork)
Record of fire/water damage
Any recent renovation
Floor area and occupancy density
Office type (open office or private room etc.)
Partition finish
Floor, wall and ceiling finishes
No. of computers, fax machines and printers
Smoking/non-smoking
Air cleaners
Pest control
Use of chemicals
Proximity to restaurant chimney

Group IV
Medical/ sickness symptoms (at work and go away after work)

Dry, itching or irritated eyes
Runny nose, stuffy nose or sinusitis
Sneeze
Sore or dry throat
Cough
Phlegm
Shortness of breath on exertion
Wheeze or difficulty in breathing
Nausea
Headache
Dizziness
Dry skin or itching skin
Skin allergy
Unusual tiredness or fatigue
Hard to remember or difficult to concentrate
Gastric or discomfort
Aching of muscle
Diarrhea
Fever

5.3 Results

5.3.1 The full set of significant correlations (at $p<0.01$) is listed in Appendix VIII. Some of the correlations are debatable as to whether there is indeed any direct influence of one factor upon the other. For the purpose of this study, the justification of the use of occupants' perception as a measure of sick building syndrome is the main task. The results listed below focus on this task.

PM3006517382
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

5.3.2 *Perception of Indoor Air Quality (IAQP)*

The significant and useful correlations are:

Group II	Group III
Carbon dioxide	Occupancy density
Carbon tetrachloride	New carpet
Chloroform	Re-partitioning
Bacteria	No. of computers, fax machines, printers & lighting
Cigarettes per day at work	Odour (tobacco, chemicals, body, mould)
Temperature	Adjacent to restaurant chimney
Humidity	
Air change	

5.3.2.1 For Group IV, the whole list has significant correlation. These results indicate that the perception of occupants on IAQ showed significant reflection of their health condition which were represented by 21 symptoms.

5.3.2.2 There are however observations which are not logical at first glance: in Group II, there is negative correlation with formaldehyde, toluene, xylene, trichloroethylene and chloroform. One plausible explanation could be the fact that these are organic chemicals related to new decorations and new furniture. For offices with relatively high levels of these compounds, they are also relatively new. The newness of the work environment has led to a perception that the indoor environment is good, but not necessarily the air quality.

5.3.3 *Building Symptom Index (BSI):*

5.3.3.1 This is a count of how many of the six symptoms disappear upon leaving the workplace and should be more objective than the IAQP.

The significant correlations observed are:

Group II	Group III
Carbon Tetrachloride	No. of lighting elements
Trichloroethylene	Use of cleaning agents
Dust borne fungi	Repartitioning
Temperature & relative humidity	Cigarettes per day
Cigarettes per day at work	

5.3.3.2 Group IV shows significant relationship on all symptoms. The BSI has been drawn up and tested by USEPA and is undergoing continuing refinement. In any case it appears to be a sub-group of IAQP in the list of significant and useful correlations. In the same manner it also shows negative correlations with formaldehyde, toluene etc.

5.3.4 *Sick Leave Frequency*

The significant correlations are listed below:

Group I Group IV

PM3006517383

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Cigarettes per day at work Air change Temperature Humidity	Teary/ Blurred vision Dry eyes

5.3.4.1 The percentage of people actually taking sick leave was much lower than those who did not feel well. This has been shown in the questionnaire survey that whilst over 3% (average) expressed that they had suffered from colds/flu during the past month, the sick leave days are less than 1%. This also compares well with general observations in the private sector where frequent sick leave reflects poorly on the worker's attitude and also they have to submit a doctor's certificate for taking sick leave, at their own cost.

5.3.4.2 The sick leave correlations are again a subset of IAQP, and shows some relationship between sickness and the work environment.

5.4 Projection of Percentage of Sick Building

5.4.1 The methodology for the projection involves matching the overall dissatisfaction with that in sick building and non sick building, i.e.,

$$Pt = P * Ps + (1-P) * Pns$$

where,

Pt = proportion of people reporting dissatisfaction in the telephone survey
P = proportion of sick buildings
Ps = proportion of people reporting dissatisfaction in sick building
Pns = proportion of people reporting dissatisfaction in sick building in non-sick building

Re-arranging this formula gives:

$$P = (Pt - Pns)/ (Ps-Pns)$$

5.4.2 From this, the P value was calculated based on 1000 simulations of Pt, Ps and Pns from their sampling distributions.

5.4.3 There are three factors not accounted for:

(a) Some people in the telephone survey may work in the same building as the on-site survey. This is not important as the overlaps are small.

(b) Buildings with different occupancy levels have different probability of being selected in the telephone survey. This is only an issue if the size of building is strongly linked to air quality.

(c) The possible error in the classification of sick buildings is ignored: this exists regardless of the projection.

PM3006517384
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

5.4.3.1 The assumption made is that the 19 sick buildings are representative of sick buildings and the 21 are representative of the non-sick buildings. Assuming that the telephone survey is a representative sample of people working in the right type of buildings, we then use the telephone survey results to estimate the proportion of sick building.

5.4.3.2 The projection gives the result of percentage of sick building as:

32% with a 95% confidence interval (CI) of (21%, 44%)

5.4.4 *Results and Discussion*

5.4.4.1 The best estimate of the proportion of centralised air-conditioned buildings that are sick buildings (based on 1000 simulation) is 32% with a 95% confidence interval of (21%, 44%) for all buildings (offices) in Hong Kong. This compares well with the WHO percentage of one third of the population suffers from sick building syndrome.

5.4.4.2 The Spearman's correlation demonstrates how perception indicators, such as IAQP can be used to illustrate that there may be problems with the IAQ at the work place. These perception indicators however can sometimes be overshadowed by what is pleasing to the eye, such as a newly decorated office. The subtle effect of low levels of chemical exposure may not be detected by the sensory organs of the human body.

5.5 Regression Analysis

5.5.1 In this section, the results of the stepwise multiple regression analysis are interpreted.

5.5.2 The 3 major concerns are as follows:

- Perception of air quality in office
- Building Symptom index (BSI)
- Sick leave

5.5.3 In the regression model, these concerns become the dependent variables. The independent variables are made up of parameters associated with architectural design and building management. The variables are combined within each of the groups to identify the regression model which can best quantify the variability of the relationship.

5.5.4 *Perception of Air Quality in Office*:

The first regression analysis is to predict the linear relationship when the variables from architectural design are combined together, which is followed by regression based on variables from building management services.

5.5.5 *Equation 1 (Architectural design related variables)* :

From the regression analysis using architectural design related variables and the perception of air quality in office to predict the relationship of the model, the equation is as follows:

$Y = a + b_i X_j$

where:

Y = perception on air quality in office

b_i = relative humidity (ranked), temperature (ranked), HVAC system$_m$ (HVAC system 1-8, 2-8, 3-8, 4-8, & 5-8), district$_n$ (district 1-16, 2-16, 3-16, 4-16, 5-16, 6-16, 7-16, 8-16, 11-16, 13-16, 14-16 & 15-16)

PM3006517385

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

$X_j = X_1 + X_2 + ... X_j$

In substituting the results, the regression line can be fitted as follows:

$$Y = 3.4819 - 0.0008 X_1 + 0.0005 X_2 + 0.1773 X_3 + 0.2033 X_4 - 0.4286 X_5 + 0.0211 X_6 + 0.3127 X_7 - 0.4938 X_8 + 0.3494 X_9 + 0.1449 X_{10} + 0.0317 X_{11} - 0.3612 X_{12} - 0.0383 X_{13} + 0.6771 X_{14} + 0.3004 X_{15} - 0.4668 X_{16} + 0.3627 X_{17} + 0.0309 X_{18} - 0.3822 X_{19}$$

i.e., the respective coefficients and variables are:

Coefficients	Variables (Architectural Design Related)		
- 0.0008	X_1	Relative Humidity	
0.0005	X_2	Temperature	
0.1773	X_3	HVAC System 1	VAV, Dual conduit
0.2033	X_4	HVAC System 2	VAV, Reheat
- 0.4286	X_5	HVAC System 3	VAV, Modified dual conduit
0.0211	X_6	HVAC System 4	FCU
0.3127	X_7	HVAC System 5	CAV
- 0.4938	X_8	District 1	Island West
0.3494	X_9	District 2	Sheung Wan
0.1449	X_{10}	District 3	Central
0.0317	X_{11}	District 4	Wan Chai
- 0.3612	X_{12}	District 5	Causeway Bay
- 0.0383	X_{13}	District 6	North Point/Quarry Bay
0.6771	X_{14}	District 7	Other part of HK Island
0.3004	X_{15}	District 8	Tsim Sha Tsui
- 0.4668	X_{16}	District 11	Cheung Sha Wan
0.3627	X_{17}	District 13	Other part of Kowloon
0.0309	X_{18}	District 14	Tsuen Wan
- 0.3822	X_{19}	District 15	Sha Tin

In this case, the proportion of variation explained by the model (R^2) is 0.1020 (i.e., these variables together explain about 10% of the variance).

5.5.6 Equation 2 (Building management services related variables) :

5.5.7 From the regression analysis using building management services related variables and the perception of air quality in office to predict the relationship of the model, the equation is as follows:

$Y = a + b_i X_j$

where:

Y = *perception on air quality in office*

b_i = relative humidity (ranked), temperature (ranked), $HVAC_t$ (HVAC system 1, 2, 3, 4 & 5), density of fans, wall $cover_m$ (wall cover1, 2, 3, 4 & 5), no. of return air vents, $smoking_n$ (smoking 1, 2, 3 & 4), $odour_o$ (at workspace 1 & 2), use of odour removal and the use of marker $pens_p$ (2 & 3)

$X_j = X_1 + X_2 + ... X_j$

In substituting the results, the regression line can be fitted as follows:

PM3006517386

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

$$Y = 3.7354 - 0.0004 X_1 + 0.0003 X_2 + 0.0469 X_3 + 0.2583 X_4 - 0.7330 X_5 + 0.0108 X_6 + 0.3725 X_7 + 26.6531 X_8 - 0.3167 X_9 - 0.4925 X_{10} - 0.0793 X_{11} - 0.5291 X_{12} + 0.2019 X_{13} + 0.0225 X_{14} + 0.0527 X_{15} + 0.1981 X_{16} - 0.0197 X_{17} - 0.3964 X_{18} + 0.4097 X_{19} - 0.0400 X_{20} - 0.2883 X_{21} - 0.2180 X_{22} - 0.0372 X_{23}$$

i.e., the respective coefficients and variables are:

Coefficients	Variables (Building Management Services Related)		
- 0.0004	X_1	Relative Humidity	
0.0003	X_2	Temperature	
0.0469	X_3	HVAC System 1	VAV, Dual conduit
0.2583	X_4	HVAC System 2	VAV, Reheat
- 0.7330	X_5	HVAC System 3	VAV, Modified dual conduit
0.0108	X_6	HVAC System 4	FCU
0.3725	X_7	HVAC System 5	CAV
26.6531	X_8	Density of Fans	
- 0.3167	X_9	Wall Cover 1	Latex/solvent-based paint
- 0.4925	X_{10}	Wall Cover 2	Wood panelling
- 0.0793	X_{11}	Wall Cover 3	Wall Paper
- 0.5291	X_{12}	Wall Cover 4	Marble
0.2019	X_{13}	Wall Cover 5	Others
0.0225	X_{14}	No. of Return Air Vents	
0.0527	X_{15}	Smoking 1	Permitted in office
0.1981	X_{16}	Smoking 2	Not permitted in work place
- 0.0197	X_{17}	Smoking 3	Only in cordoned off area
- 0.3964	X_{18}	Smoking 4	Only in corridor
0.4097	X_{19}	Odour (at workspace 1)	Chimney of restaurant in vicinity
- 0.0400	X_{20}	Odour (at workspace 2)	Traffic emission
- 0.2883	X_{21}	Use of Odour Removal	
- 0.2180	X_{22}	Use of Marker Pens (2)	Less than once/day
- 0.0372	X_{23}	Use of Marker Pens (3)	Rarely/never

5.5.8 In this case, the proportion of variation explained by the model (R^2) is 0.236 (i.e., these variables together explain 24% of the variance).

5.5.9 The same regression analysis model was applied to building symptom index (BSI) and sick leave. However, the predictions of these two dependent variables by combining the independent variables have been poor (i.e., the proportion of variation explained by the model is only less than 10%).

5.6 Radon Analysis For Residential Sector

5.6.1 The Environmental Protection Department (EPD) has conducted a study of the radon concentration levels in residential premises in Hong Kong between 1992/93. The dataset was given to EHS for analysis.

5.6.2 A total of 1,784 cases were measured covering 19 districts. Various building characteristics (i.e., by the type of variables) have been considered in EPD's study.

5.6.3 Regression analysis is used to find the best fit model to predict the concentration level of radon (R_n). Repeat of the analysis was made at the request of EPD with new dataset subsequently provided by EPD and the regression analysis model is as follows:

$$R_n = e^{(A+B)}$$

where,

$A = 4.6304 + \sum$ (coefficient from each category of variable related to the premises)

PM3006517387

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

$B = \sum [\ln (\text{variable}) * \text{coefficient of each variable}]$

Premises characteristics (coefficients are estimated for the following variables)	
District	Duration of window opened
Location	Floor cover type
Geology	Wall cover type
Building type	Building age level
Building material	Type of ventilation
Room type	Pollution
Floor number level	Number of smokers
Size of window opening	

Variables (numbers are recorded from observations)	
Total area	Window sizes
Floor area	Number of people
Height	

5.6.4 By regressing radon concentration as the independent variable with other variables in the radon study combined, a total of 15 variables as shown in the above are found to explain 22% of the variance.

5.6.5 *Significant Findings by EPD*

5.6.5.1 Repeat measurement aimed at reviewing the effectiveness of public awareness campaign on the mitigation for dispersion of radon in the homes was carried out by EPD. The results of the follow up study of residential premises conducted between 1995/96 revealed that the mean concentration level of radon using ATDs was 78 Bq/m^3 with 5.5% of the surveyed premises exceeding 200 Bq/m^3. There has been a slight drop in the radon concentration level compared to the previous study.

5.6.5.2 According to EPD, the improvement in the radon concentration level is probably due to the public's response to its pamphlet which documented steps that public may take to reduce the radon level in homes.

5.6.5.3 The public are informed that simple mitigation measure such as opening windows to increase the natural ventilation of homes is sufficient to bring radon level below the standard deemed to be harmful to human health. A lowering of the radon concentration level would help to minimise human exposure.

5.7 Conclusion

The statistical analysis shows that about one-third of the office premises surveyed in this IAQ study may be categorised as sick building. This comes close to the findings by the WHO. The regression analysis revealed a strong relationship between perception by office occupants on the air quality and the variables associated with architectural design and building management.

PM3006517388

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

6. REVIEW OF PRACTICE IN SELECTED COUNTRIES

6.1 Introduction

6.1.1 This part of the study covers eight countries and focuses on their relevant legislations, regulations and current practices on the control and understanding of the indoor air quality issue. The information was collated by local consultants at their respective countries with particular attention to the establishment of standards and control mechanism. A study of the experiences in other countries provides the background information to the status of IAQ in these countries and the information is particularly useful in formulating the strategy to institutionalise IAQ for Hong Kong.

6.1.2 The following is an abridged version of the study containing the salient points for discussion.

6.2 AUSTRALIA

6.2.1 *Legislative Framework*

6.2.1.1 In Australia, IAQ legislation falls under the two categories: i) Occupational Health and Safety; and ii) Public Health. It differentiates industrial workplace pollution (Occupational Health and Safety) from indoor air pollution (Public Health). Buildings regulated under the Public Health include homes, schools, restaurants, public building, residential institutions and offices.

6.2.1.2 Each of the nine jurisdictions in Australia has a different set of legislation. The administration of IAQ related legislation and standards is the responsibility of individual States or Territories. The Federal government agencies are mainly involved in co-ordinating research, developing and implementing national strategies, and producing model legislation and standards.

6.2.2 *Worksafe Australia and the National Health and Medical Research Council*

6.2.2.1 IAQ standards are developed by two main federal agencies: i) the National Occupational Health and Safety Commission (Worksafe Australia), a tripartite body who addresses the issue of IAQ in the workplace; and ii) the National Health and Medical Research Council (NHMRC), it takes a public health approach in IAQ issue. The standards developed by both agencies are often called up in relevant legislation of the various jurisdictions.

6.2.2.2 Standards Australia come from the Standards Association of Australia (Standards Australia) which is an independent, non-profit making professional body. Through open consultation, it develops a wide range of national standards, including IAQ standards. The standards will become mandatory if called up in the legislation. Other standard setting bodies have developed IAQ standards in specific areas, but they only serve as industry standards or advisory guidelines.

6.2.3 *State Legislation*

6.2.3.1 The principal Occupational Health and Safety statute in all jurisdictions laid the duties on all parties concerned in a broad sense. It is supported by regulations which address the minimum standards in specific areas. For example, the minimum ventilation requirements for air-conditioned workplace is often addressed in State regulations to deal with specific IAQ issue. Under the principal statute, codes of practice can also be approved by ministers of the

PM3006517389

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

individual jurisdictions. They provide guidance to employers and employees for the compliance with the principal statute and regulations. Codes of Practice are where most IAQ related standards can be found.

6.2.3.2 Various jurisdictions also publish guidance documents, providing information and guidance to the public for the development of healthy and safe workplace. However, unlike the regulations under the principal statute, they have no legal status.

6.2.4 IAQ Standards

6.2.4.1 Interim National IAQ Goals

6.2.4.2 In 1989, the NHMRC recommended that the Interim National Indoor Air Quality Goals could be established by adopting the Ambient Air Quality Goals. Another interim goal on total volatile organic compounds (TVOC) was recommended in 1993, setting standards for carbon monoxide, formaldehyde, lead, ozone, radon, sulphates, sulphur dioxide, total suspended particulate and TVOC. The Goals, however, are very much a set of advisory guidelines.

6.2.4.3 The Worksafe Australia has published a set of national exposure standards, equivalent to the TLV in the USA.

6.2.4.4 Standards on Mechanical Ventilation

Australian Standard AS 1668.2 "The use of mechanical ventilation and air-conditioning in buildings Part 2; Mechanical ventilation for acceptable indoor-air quality" is widely accepted as the principal industry standard on ventilation throughout Australia. It consists of three parts: i) Supply Air Dilution Procedure which prescribes the minimum outdoor-air requirements that are similar to ASHRAE 62; ii) Exhaust Air Dilution Procedures sets out the air discharge requirements for exhaust ventilation; iii) Other specific ventilation requirements for enclosures such as car parks. Although this Standard does not cover thermal comfort, the subject is addressed in various Codes of Practices and Guidance Documents in State legislation.

6.2.4.5 Legionnaires' disease and Air-handling/Water System, and Passive Smoking

(i) Legionnaires' disease and passive smoking are the only two IAQ issues found in the Public Health legislation. Australian Standard AS3666 is the principal standard on the control of micro-organisms in air-handling and water systems. It sets out requirements on the materials, construction, location, inspection and cleaning frequency for various components. The Standard are now enforced in building regulations, with accompanying guidelines on how to comply with the Standard.

(ii) Several legislative provisions specifically ban smoking or regulate smoking in areas related to food hygiene, dangerous goods, mines, passenger transport and government buildings. Worksafe Australia released a national guidance document "Guidance Note of Passive Smoking in the Workplace" in 1994, stating its policy on a smoke-free environment in workplace through gradual implementation of programmes and consultation with employees. In New South Wales, a Code of Practice providing guidelines on how to discharge duties in relation to passive smoking has been issued under the Occupational Health and Safety Act.

6.2.4.6 Other IAQ Standards

(i) "Managing Indoor Air Quality", a guidance document published by the Building Owners and Mangers Association (BOMA) in 1994, gives advice to building manager and others to improve IAQ in buildings through good management practices. "The

PM3006517390

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Building Code of Australia" published by the Australian Uniform Building Regulations Co-ordination Council provides guidelines on building designs leading to acceptable IAQ.

(ii) IAQ in domestic premises is only addressed by regulations or standards on the manufacture and installation of appliances.

6.2.5 *Difficulties in IAQ Management*

6.2.5.1 Although federal agencies have developed national guidelines on IAQ, the regulatory control in Australia is still fragmented and lack uniformity. IAQ standards of the nine jurisdictions are scattered throughout the Occupational Health and Safety legislation and the Public Health legislation. Further, their administration is shared by many government departments at the three levels of the government. A national strategic plan on IAQ and concerted efforts by all interested parties are much needed to effectively promote and improve the air quality in the built environment in Australia.

6.2.5.2 A major cause of IAQ complaints is the inadequate maintenance of ventilation systems. This is despite the clear standards on mechanical ventilation. Another problem is associated with poor ventilation designs in older buildings which render maintenance very difficult.

6.3 CANADA

6.3.1 *IAQ Legislation, Regulations and Standards*

(i) There is no IAQ legislation per se in Canada. The Canadian philosophy is to make use of ASHRAE expertise and avoid casting pollutant limits and ventilation guidance in legislation that is not easily changed. Therefore, IAQ standards like ASHRAE, AIHA and ACGIH are widely adopted by the Federal and Provincial governments in setting IAQ regulations.

(ii) The responsibility to make regulations and set standards for IAQ is with the provincial government except in areas of Federal constitutional jurisdiction such as federal government buildings, transportation, agriculture and banks. Municipal government can legislate higher standards in buildings not owned or regulated by the superior governments and this power is usually used for further restriction on smoking.

(iii) In non-industrial workplace, the Federal and Provincial governments can impose the ASHRAE ventilation standards. As IAQ in non-industrial workplace is mainly the responsibility of the Provincial governments, the regulation varies with the jurisdiction. Most provincial regulations focus on the problem of exposure to chemical agents in the workplace by specifying some form of maximum exposure limits, generally ACGIH's TLVs. Some jurisdictions prescribe minimum ventilation requirements which apply to all types of workplaces. Only one or two of the smallest provinces do not require ASHRAE standards.

(iv) Residential IAQ is legally governed under the National Building Code, which specifies methods for construction, energy-saving and IAQ. The National Building Code is prepared by expert committees organised by Canada Mortgage and Housing Corporation and the National Research Council. Once the standard is prepared, the Provinces adopt whichever parts of the standard according to their own needs. The Code is revised every few years to include up-to-date methods and technologies.

6.3.2 *IAQ Guidelines*

PM3006517391

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

The Federal-Provincial Committee on Occupational Safety and Health has had three working groups on IAQ since 1987 producing three sets of guidelines:

- Residential Indoor Quality Guidelines (1987)
- Air Quality in Office Buildings: A Technical Guide (1993; 1995)
- Fungal Contamination of Public Buildings : A Guide to Recognition and Management

These committee and working groups provide a process where government can work towards common practices and goals to improve IAQ. The committee has set targets to monitor the IAQ development in residential housing.

6.3.3 *IAQ Management and Enforcement*

6.3.3.1 Non-industrial Workplace

(i) The Federal government conducts or sponsors IAQ research for the non-industrial workplace conducted mainly by the Department of Natural Resources, the Department of Public Works and Government Services, and the Department of Health. Federal IAQ research mainly deals with: a) developing methods of construction that improve IAQ; and b) developing codes of practice and analytical tools to ensure that the standards can be followed.

(ii) IAQ policy for Federal employees is made by the Treasury Board and administered by the Department of Health. Under the policy, buildings are required to be audited for IAQ from time to time. In addition, the Federal Department of Labour (part of the Department of Human Resources and Development) has the authority to require building owners, including the Federal government, to adhere to ASHRAE and ACGIH TLV standards for common indoor air pollutants or the consensus guidelines in "Air Quality in Office Building: A Technical Guide'. Similarly, provincial governments administer their IAQ policies on non-industrial workplace through the Labour or Human Resources Department.

(iii) In addition, workers are also protected under the regulation on occupational safety and health under Part II of the Canada Labour Code. The Code is administered by Labour Canada. Various standards, e.g. noise, illumination, electrical safety, etc., were prescribed throughout the regulations issued in pursuant to the Code. The Code also empowers the Minister of Labour to prescribe standards for ventilation, temperature and humidity.

(iv) As workplace internal responsibility and voluntary compliance with the law are encouraged, the Canada Labour Code requires all business above a certain size to form a Job Occupational Health and Safety Committees represented by workers. Such committee has the power to consider and expeditiously dispose of complaints relating to the safety and health of the employees and IAQ. If a problem has remained unsolved, and employee may choose to bring the matter to the attention of the government authorities.

(v) Upon receiving a complaint, IAQ investigation is carried out. A guide which outlines the protocol for such investigation is provided by Labour Canada to assist the Officer in the investigation of IAQ complaints. Both Federal and Provincial labour inspectors can issue orders to remediate unacceptable situations and can literally shut down a building until the rules are followed. Failure to comply with the orders can result in fines and jail terms.

PM3006517392

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

6.3.3.2 Residential

Canada Mortgage and Housing Corporation is active in promoting IAQ in residential housing. Its activities include: sponsoring studies on the effects of residential IAQ on health; producing guides, videos and other material on IAQ for consumers, ranging for the average consumer to environmentally-sensitive; conducting training program for house inspectors specifically for IAQ; and chairing a national committee on VOC emissions from household products and producing a guide to low-emitting materials. However, unlike non-industrial workplace, there is a lack of enforcement mechanism to require the safety and health requirements and IAQ standards be adhered to in private home.

6.3.4 *Difficulties in IAQ Management*

The problem in implementing the IAQ guidelines are more prevalent for residential housing, private sector office building, school and university than non-industrial workplace. The first reason being that the private sector responds slower to the market needs as opposed to the non-industrial workplace where more money is at stake. Secondly, time is needed to train people to recognise IAQ problem and enact appropriate solution. Even with the growing supply of trained consultants, their service can be prohibitively expensive with limited price competition.

6.4 JAPAN

6.4.1 IAQ Legislation and Administration

The legislation and administration of IAQ in Japan place great emphasis on the roles of the building owners, maintenance technicians and building maintenance companies in the installation and maintenance of ventilation systems.

6.4.1.1 The Law for Maintenance of Sanitation in Building

6.4.2 (A) The law was introduced by the Ministry of Health and Welfare in 1970. It embodies:

(i) *Building Sanitation Management Standards* - The standards cover maintenance and management of air quality, maintenance of supplied water and wastewater, and cleaning of buildings and pest control. The standards of air quality include particulate, carbon monoxide, carbon dioxide, temperature, humidity and air velocity. They have to be met and monitored bimonthly.

(ii) *Obligation of owners of "specially designated buildings"* - The "specially designated buildings" are buildings with a total floor area of more than 3,000 m^2 (8,000 m^2 for schools) used for i) places for entertainment, department stores, assembly halls, libraries, museums, art museums and game houses, ii) stores and offices, and iii) hotels and inns.

(iii) *Appointment of Building Environment Sanitation Management Technicians* - To be qualified as Building Environment Sanitation Management Technicians, individuals have to sit for a national examination or complete the training course organised by the Ministry of Health and Welfare.

(B) Administrative Responsibilities

(i) In enforcing the Law for Maintenance of Sanitation in Building, the Environmental Health Bureau of the Ministry of Health and Welfare provides guidance to all prefectures and cabinet order-designated cities, and building maintenance companies. The two parties in turn notify the Bureau of their work.

PM3006517393

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

(ii) Building maintenance companies offer maintenance and management services to meet the Building Sanitation Management Standards. Whereas owners of the buildings appoint Building Environment Sanitation Management Technician to ensure that the buildings' IAQ comply with the Standards. If the Standards are not met, the governor or mayor could order the building owners to rectify the situation or subject them to fine or closure of the buildings.

6.4.2.1 Ministerial Ordinance of Sanitation in Buildings

This Ordinance was enacted by the Ministry of Health and Welfare in 1971 and revised in 1974 and 1977. It stipulates the acceptable level of carbon monoxide concentration for indoors and the procedures for measurement of suspended particulate, carbon monoxide, carbon dioxide, room temperature, relative humidity and air velocity in rooms of buildings.

6.4.2.2 Ministerial Ordinance of Sanitation in Offices

This Ordinance was enacted by the Ministry of Labour in 1972 and revised in 1976. It specifies the occupancy space for office workers and the required total openable window areas in relation to the floor area. The room temperature, relative humidity, air velocity and concentration of suspended particulate are set in line with the Building Sanitation Management Standards.

6.4.3 IAQ Guidelines

6.4.3.1 Guideline for Prevention of Legionella Disease

In 1993, the Ministry of Health and Welfare issued a Guideline for the Prevention of Legionella Disease. Recommended preventive measures focus on selection of building materials, maintenance procedures and treatment of circulating water.

6.4.3.2 Guidelines for Ventilation System

Under the supervision of the Ministry of Construction, three guidelines are published and revised annually to assist in the design of ventilation and air conditioning systems. They are: i) Guidebook for Execution and Supervisory of Mechanical Equipment Work; ii) Common Specification of Mechanical Equipment Work; and iii) Standard Chart of Mechanical Equipment Work. Industrial standards relating to air conditioning facilities are also available.

6.4.3.3 Volatile Organic Compounds (VOCs) in Indoor Air

No VOC guidelines are adopted in Japan, but the World Health Organization's Air Quality Guidelines for VOCs are used for reference.

6.5 SOUTH KOREA

6.5.1 IAQ Legislation and Regulations

The Indoor Air Quality Management Law was proposed in 1995 but has not yet been enacted. Before the enactment of the law, regulations and standards on IAQ stipulated in various laws are implemented separately by three ministries.

6.5.1.1 Regulations Implemented by the Ministry of Health and Welfare

(A) The Public Sanitary Law

PM3006517394

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

The Public Sanitary Law is aimed at maintaining the IAQ standards in public facilities to minimise the adverse health effects to the general public. The 'public places' identified include office buildings, theatres, department stores, underground shopping arcades, hotels, hospitals, airports and transportation systems. The air quality standards were developed in respect of total suspended particulate, carbon monoxide, carbon dioxide, temperature, relative humidity, illumination and air movement velocity. Some standards are adopted from the US and Japan.

(B) The Indoor Air Quality Management Law

This Law has yet to be enacted. With new IAQ standards, it is meant to replace and strengthen the Public Sanitary Law. It is expected to be enforced jointly by the Ministry of Health and Welfare and the Ministry of Environment.

(C) The Food Sanitary Law

Effective January 1962, the Food Sanitary Law specifies the requirement on proper ventilation systems in restaurants. However, IAQ standards are not applied.

(D) The Public Health Law

This Law enacted in early 1996, is the most stringent regulation prohibiting smoking in public places. The owner or responsible authority of 'public places' has to ban smoking. It requires the provision of a specified smoking area inside or outside the building, equipped with proper ventilation. The type and capacity of ventilation system are however not specified for under the Law.

6.5.1.2 Regulations Implemented by the Ministry of Construction and Transportation

(A) The Architecture and Construction Law

This Law requires the use of ventilation systems in public facilities to maintain IAQ standards as prescribed in the Public Sanitary Law. It does not specify the types and capacities of ventilation systems used.

(B) The Underground Parking Place Law

The Law requires ten air change per hour in large underground parking places. A recent revision specified that the ventilation system must maintain the level of CO below 50 ppm for 8 hours.

6.5.1.3 Regulations Implemented by the Ministry of Environment

(A) Air Quality Guidelines for Underground Spaces

This Guidelines were implemented in 1990. A total of 14 air quality parameters were set for underground spaces including railway stations and arcades. It will be refined when the proposed legislation on Indoor Air Quality Management is enacted.

6.5.2 Problems in Implementing IAQ Regulations

Four major difficulties in implementing the IAQ regulations in South Korea have been identified: i) Despite numerous existing IAQ regulations, they are not integrated and specific

PM3006517395

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

enough; ii) Without governmental expert groups to ensure an effective IAQ management, the terminology and technical specifications adopted are often unclear; iii) Given the lack of reliable database on IAQ, guidelines and standards adopted from countries like US and Japan may not be suitable for South Korea; iv) The IAQ Management Law was solely prepared by the Ministry of Environment, even though inter-departmental and inter-disciplinary solutions are required to deal with the IAQ issue.

6.6 SINGAPORE

6.6.1 *IAQ Management and Regulation*

Four government bodies are involved in the planning and development of IAQ in Singapore. They sets regulations, standards, guidelines, and Code of Practice to monitor IAQ. They may also propose their standards or adopt standards like ISO, ANSI and ASHRAE.

6.6.1.1 Ministry of Environment

(i) The Ministry has established the Technical Advisory Committee on IAQ. In 1992, they published the Code of Practice for the Control of Legionella Bacteria in Air-Conditioning Cooling Tower in Singapore. The Code contains guidelines on the location of cooling towers, frequency of servicing and maintenance, use of chemicals and biocides, record keeping and emergency remedial measures in the event of an outbreak.

(ii) In late 1996, the Ministry published the Guidelines for Good Indoor Air Quality in Office Premises, providing general guidance and action plan for improving the IAQ of air-conditioned office premises. The Guidelines set out maximum concentrations for specific indoor air contaminants and values for specific physical parameters such as temperature, humidity and air movement. It is intended to complement the engineering specifications set out in the Singapore Code of Practice for Mechanical Ventilation and Air-Conditioning in Building.

(iii) The Guidelines also include information on the potential health effects of indoor contaminants and the maintenance of good IAQ in a building at different stages: design, construction, commissioning and operation, and renovation. They recommend a maintenance schedule for the ventilation system and an audit at least every two years.

6.6.1.2 Ministry of National Development

The Ministry of National Development is responsible for the administration of the Building Control Regulations, which are issued pursuant to the Building Control Act 1989. The Regulations are set for design and construction of buildings, and applied to all new and renovated construction. The Singapore Code of Practice for mechanical ventilation SS:CP 13:1979 described the standard. Also, the design values for HVAC prescribed cater for the hot and humid conditions in Singapore allowing a higher comfort zone than ASHRAE.

6.6.1.3 Ministry of Labour

The Ministry is responsible for industrial and occupational standards relate to worker health and safety. The Ministry addresses problems as they arise from complaints, emergencies and accidents through a committee of enquiry and investigative reports. Specific testing may be required to verify a situation by applying certain test methods and procedures prepared by the Singapore Institute of Standards and Industrial Research (SISIR), which prepares the legal background for IAQ-related standards and develops test methods.

6.6.2 *Non-Governmental Bodies*

(i) As highly technical scientific expertise is required in the preparation of standards and codes, consultants for industrial, commercial and health groups are involved. Also, as

PM3006517396

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

these non-governmental bodies represent the interests of those who will use or be affected by the standards and codes, their participation on the IAQ development is important. Manufacturers of instrumentation for IAQ monitoring and the local agents are also consulted for their practical expertise.

(ii) The International Facility Management Association (IFMA) active with building services has participated in IAQ development.

6.6.3 *Major IAQ Problems*

Most buildings in Singapore suffer from insufficient or no exhaust air and insufficient outside air makeup. The solution could be setting standards and codes on contaminant exhaust flows or decontamination flows and fresh air intake. This highlights the importance of the design and construction of the HVAC system, as well as the maintenance of air filter. However, obstacles to resolving the IAQ concern are present with the insufficient operation control of buildings and the cost needed for compliance with the regulations. Structural degradation is also a rising concern.

6.7 Sweden

6.7.1 *IAQ Legislation and Code of Practice*

IAQ legislation in Sweden focuses mostly on ventilation system. IAQ related legislation includes: i) the Ventilation and Air Quality Ordinance (ASF 1993:5), and ii) Ordinance SFS (1991:1273). The former deals with the requirements on the installation and maintenance of ventilation system, while the latter on the technical and functional control of ventilation system. Under each Ordinance is a set of Code of Practice which provides rules, guidelines, and standards for IAQ.

6.7.1.1 Ventilation and Air Quality Ordinance (ASF 1993:5)

Harmonized with the European Union rules for IAQ and written by the National Board of Occupational Safety and Health, the Ventilation and Air Quality Ordinance (ASF 1993:5) contains directions on ventilation and air quality in occupational environments, including personal premises. The Ordinance requires all occupational premises to be equipped with ventilation system to remove air pollution and ensure a satisfactory level of air quality; appropriate cleaning devises; and indicator devices to measure the amount of pollutants in the recirculated air. The Ordinance also sets out requirements on written instruction, knowledge of maintenance personnel, inspection and record keeping for the installation and maintenance of mechanical ventilation.

An illustration booklet, the National Board of Occupational Safety and Health Advice on the Application of Ordinance, provides guidelines for the interpretation and application of the Ordinance.

Code of Practice on Ventilation

Details of the directions under the above Ordinance are set out in this Code of Practice. The Code includes recommended ventilation rates for various indoor facilities; a minimum level of 0.5 air change per hour or 4 l/s per person; and standards for air pollutants such as radon, formaldehyde, carbon dioxide and carbon monoxide.

New rules for IAQ are being discussed within the European Union and the Board of Health and Social Welfare of the Swedish government is reviewing its rules to assess the sanitary nuisance of moulds indoors.

PM3006517397

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

6.7.1.2 Ordinance (SFS 1991:1273)

National Board of Housing, Buildings and Planning (NBHBP) is mainly responsible for the application of the Ordinance SFS 1991:1273. The Ordinance aims at ensuring a functional control of the ventilation system in buildings. It requires the owner of the building to be responsible for the execution of function control before the ventilation system is put in use and thereafter at regular intervals. The function control is required to be executed by trained technicians authorized by the NBHBP. The detailed rules set out in the Code of Practice illustrated below are issued and regularly updated by the NBHBP.

6.7.1.3 Code of Practice in Ventilation Air Duct Cleaning

The Code of Practice specifies different classes of authorized inspectors; requires a protocol to be established for every inspection and this is posted at a prominent location in the building; defines penalties for any violations of the rules; specifies duct-cleaning methods, value and maximum level of air movements, levels of carbon monoxide and radon; and also set different time intervals for regular inspections (e.g. 2 years for day-care centres, schools and hospitals; 3 years for residential and office buildings with control over incoming and outgoing air; 6 years for those with control over outgoing air only; and 9 years for those without air control.)

6.7.2 *Government Structure of IAQ Management*

6.7.2.1 Government and Non-government Bodies

IAQ is dealt with by several authorities in Sweden. In additional to the National Board of Housing, Buildings and Planning (NBHBP) mentioned above, other authorities include the Board of Health and Social Welfare (BHSW) and building authorities in the municipalities. BHSW mainly responsible for setting general IAQ requirements and standards for living quarters. Other bodies such as the Institute of Environmental Medicine, Karolinska Institute and some interest groups, e.g., the Asthma Foundation also play a role in promoting IAQ.

6.7.2.2 Nordic Committee on Building Regulation 1991

(i) The Nordic Committee on Building Regulation set up an indoor climate committee in 1987 to support joint Nordic activity in dealing with IAQ. Authorities from five Nordic countries are involved: Denmark, Finland, Iceland, Norway and Sweden.

(ii) The Committee came up with a five-year plan in November 1987, with a priority to review a section on IAQ in 1981 Report No. 40 on Indoor Climate. The Committee organized seminars and meetings to gather expert knowledge on IAQ, and therefore incorporated the up-to-date knowledge into the revised section of the report. The revised report outlines a strategy for the planning, construction, operation and maintenance of buildings for IAQ improvement. It serves as a basis for the regulatory authorities in different countries to form regulations and/or recommendations on IAQ.

6.7.3 *Difficulties in IAQ Management*

The major difficulty encountered in IAQ management by the Swedish authorities is to ensure proper maintenance and use of ventilation system. It is common to find cases of negligence such as fan engines not working properly and turning down of ventilation system to save energy.

6.8 UNITED KINGDOM

6.8.1 IAQ Legislation and Regulatory Framework

(i) There is no specific legislation on IAQ standards in UK. Several pieces of legislation have a bearing on IAQ but this is not their main purpose. The legislation includes housing legislation, health legislation, building regulations, and restrictions on the manufacture, use and import of certain substances.

PM3006517398

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

(ii) The European Union (EU) plays a significant role in directing policy and planning in UK. Some European standards have been incorporated into the British Standards system which reflects the direction within the EU for greater harmonisation of standard. The harmonisation process may lead the UK to adopt European environmental legislation.

(iii) Like other self-regulatory systems in the UK, IAQ standards and ventilation requirements are largely to be the responsibility of professional bodies who define guidelines which are voluntarily adopted by their members.

6.8.1.1 Health and Safety at Work Act 1974 and the Offices, Shops and Railway Premises Act 1963

These Acts cover IAQ in commercial buildings and require employers to provide a healthy and safe working environment, and that buildings should be effectively and suitably ventilated. Standards or guidelines for air quality are however not specified. The Select Committee for the Environment's Sixth Report on Indoor Air Pollution recommended that air quality guidelines and Codes of Practice should be developed for IAQ in buildings in the long run.

6.8.1.2 Building Regulations 1991

(i) All building work is governed by the Building Regulations, under the Building Act 1985. The technical specifications are provided by a series of Approved Documents which make reference to British Standards and Codes of Practice. Approved Document D sets out the requirement and the guidelines for the control of toxic substance. Approved Document F requires the provision of an adequate means of ventilation and recommends the means to meet the requirements.

(ii) British Standards contain specific provisions made for ventilation systems and building management. They include Code of Practice or guide on mechanical ventilation and air conditioning in buildings, building maintenance management, control of condensation in buildings, ventilation principles and designing for natural ventilation, and particulate air filters for general ventilation requirements, testing and marking. Some of the European standards are incorporated.

6.8.1.3 Control of Substances Hazardous to Health (COSHH) Regulation (1994)

The COSHH regulations aim to improve the control of hazardous substances in the workplace. The regulations include the Occupational Exposure Limits relating to a large number of individual organic and inorganic compounds defined and regulated by the HSE. Two exposure standards are defined: Maximum Exposure Limits (MELs) and Occupational Exposure Standards (OESs).

6.8.2 Government Structure of IAQ Management

Responsibility for planning and implementation of IAQ policy rests with the Department of the Environment (DoE). It chairs an Interdepartmental Liaison Group on IAQ to coordinate the division of enforcement responsibilities. The effectiveness of the Group has been questioned resulting in the formation of a new Environmental Protection Agency on 1 April 1996. The Agency's role is to consider the environmental issues with a wider perspective and to coordinate policy and enforcement with DoE.

Regulations on IAQ are enforced by the local authorities environmental health offices (EHOs), the DoE and other government departments, including the Health and Safety Executive (HSE). HSE enforces the Health and Safety at Work Act in factories, schools and hospitals, whereas local authorities enforce the Act in offices, shops and restaurants. HSE has also produced a set of guidance for employers, building owners and managers on how to deal with Sick Building Syndrome, and a leaflet advised employers on action to prevent passive smoking at work.

PM3006517399

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

6.8.3 Self Regulation

The Chartered Institution of Building Service Engineers (CIBSE) publishes guides on the design, installation and maintenance management of HVAC systems. The Heating and Ventilating Contractors Association (HVCA) gives specifications on maintenance of ventilation, air cleaning schedules and advises on how to avoid Sick Building Syndrome.

The Building Research Establishment (BRE) has launched a Building Research Establishment Environmental Assessment Method (BREEAM) since 1991 for the environmental labelling of buildings. Certificates are awarded to buildings stating their performance against a set of environmental criteria. Factors identified to affect IAQ are ventilation, passive smoking, humidity, lighting and thermal comfort. This is a means to distinguish buildings with positive environmental benefits to the occupiers and society. It places a high priority on design and is utilised as a model by other European countries.

6.8.3.1 Problems Encountered in Implementing Regulations and Guidelines

Problems of the IAQ regulatory system in UK include:

(i) A lack of clear enforcement roles of the regulatory agencies and the non-existence of legislation to provide a framework to regulate IAQ. The future development very much depends on the newly established Environmental Protection Agency to lead the way to the development of detailed statutory air quality criteria and clarification of roles for regulatory agencies.

(ii) The efforts to control IAQ have been incoherent. The government focuses mainly on improving IAQ at domestic housing through the upgrading of building standards, controlling products giving rise to pollution and educating people on the ways to avoid risks. Whereas, in the commercial sector, no control technologies were planned except with the policy on smoking.

(iii) The role of the professional bodies is uncertain. Despite the existence of guidelines, there is an acknowledged problem with their implementation and quality of maintenance of ventilation system. This points to the need to strengthen the role of professional bodies and education for maintenance workers.

6.9 United States

6.9.1 IAQ Legislation

(i) Drafted by the Occupational Safety and Health Administration (OSHA), an IAQ Bill passed the Senate in 1993 but still has not yet become law in the US. One of its objectives is to amend the Public Health Service Act to authorise a national program to reduce the threat to human health posed by exposure to contaminants in the air indoors. The Bill includes sections on co-ordination, guidelines for identifying, reducing, and preventing significant indoor air health risk and healthy building program.

(ii) The IAQ Bill received all round attention. The state agencies are waiting for OSHA, and OSHA is waiting for Congress and the President to come to a budget agreement. This has led to the reliance on well-defined standards and industry self-regulation driven by profit motivation and litigation avoidance.

6.9.2 *IAQ Regulations by the Federal Government*

6.9.2.1 Interagency Committee on Indoor Air Quality

PM3006517400

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

The committee is co-chaired by the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), National Institute of Occupational Safety and Health (NIOSH), the Department of Energy (DoE), and the Consumer Product Safety Commission. Ten other agencies are represented on the committee.

6.9.2.2 The Environmental Protection Agency (EPA)

The EPA regulates emissions from factories and automobiles that affect ambient air quality. It also conducts research on IAQ issues, co-ordinates federal policy making, and disseminates information. EPA's Indoor Air Division supports indoor air programs in 10 administrative regions. The IAQ research activities include program management, monitoring, health effects, exposure, risk assessment, source characterisation and IAQ control. Some of the studies are: i) The Building Assessment Survey and Evaluation (BASE) Program for Public and Commercial Buildings which is a study to develop standardised protocol and collect database on HVAC and building characteristics, environmental measurements and occupant perceptions. The database will form a baseline to assist the determination of future IAQ research need and strategy; and ii) Evaluation of an IAQ Source Management Strategy for A Large Building focused on IAQ, product selection, building flush-out and ventilation strategies used in design and construction. Other research areas are microbiological screening of the IAQ, energy analysis of applying ASHRAE 62, indoor air emissions standard, and pollution prevention techniques to reduce indoor air pollution through development of office equipment design and low-emitting /low-impact materials.

6.9.2.3 Occupational Safety and Health Administration (OSHA)

OSHA sets regulations for safety and health in the workplace, including pollutants in the industrial workplace. The regulation on pollutants are listed in ASHRAE 62-1989 Standards. In 1994, OSHA proposed an occupational standard for IAQ pollutants applied to all non-industrial workplace. The provisions require employers to develop an IAQ plan; to implement the plan through inspection and maintenance of building systems; and to implement controls for specific contaminants and their sources. Other provisions include control of tobacco smoke and control of IAQ during building renovation; as well as record keeping of maintenance, compliance programs and employee complaints. The proposal is still awaiting acceptance by the Congress.

6.9.2.4 American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)

ASHRAE is a private professional organisation with membership open to all nationalities. It establishes standards relating to building, mechanical and IAQ-specific issues to assist the industry and the public. ASHRAE Standards include guidelines for various contaminants (ASHRAE 62-1989), guidance for establishing IAQ criteria, and other specific guidance for pollutants such as aldehydes (total), asbestos, carbon monoxide, chlordane, formaldehyde, lead, nitrogen dioxide, ozone, particulate, radon, sulphur dioxide, tobacco smoke and VOCs.

6.9.2.5 Other Government Agencies

The Office of Building Technologies of the Department of Energy is responsible for ventilation and infiltration studies. The National Institute for Occupational Safety and Health (NIOSH) has two branches handling IAQ: The Health Hazard Technical Assistance Branch (HETAB) responds to requests from individual buildings, while the Industry Wide Studies Branch (IWSB) focuses on IAQ research across buildings. Research efforts at the National Institute of Standards and Technology (NIST), Department of Commerce, have focused on ventilation assessment, and airflow and contaminant dispersal modelling.

6.9.3 Guidelines for the Control of Biocontaminants

The Legionnaires' Disease Technical Work Group has produced preliminary guidelines which provide a protocol for the start-up of cooling towers, an emergency decontamination protocol, and general procedure for routine maintenance of cooling towers. Guidelines for Prevention of Nasocomial Pneumonia, issued by the Centers for Disease Control and

PM3006517401

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Prevention, describes the epidemiology, diagnosis, transmission, prevention and control measures for Legionnaires' disease.

6.9.4 *IAQ Regulation, Standards and Guidelines in Six Major States*

California, Washington, Florida, New Hampshire, New Jersey and Utah are six of the major states active in developing IAQ legislation and regulations. The regulations vary from state to state, and some have enacted their own laws regulating IAQ. ASHRAE ventilation standards are adopted in some states, e.g. Minnesota, New Hamsphire, while California and Florida have adopted their own standards.

6.9.4.1 California

Five agencies are involved in IAQ activity: i) The California Energy Resources Conservation and Development Commission (CEC) sets standards for energy conservation and minimum ventilation rates; ii) The Air Resources Board (ARB) implements the federal air quality program and sets ambient air quality and motor vehicle emission standards; iii) The California Indoor Air Quality Section (CIAQS), Department of Health Service, is responsible for co-ordinating research relating to the causes, effects and control of indoor pollution, and for providing technical assistance to the state agencies and the public; iv) The California. Division of Occupational Safety and Health (Cal/OSHA) enforces minimum ventilation standards and sets requirements to ensure the operation and maintenance of HVAC system meet the air quantity specified in the State Building Standards Code; and v) Lawrence Berkeley Laboratory (LBL) launches an Indoor Environment Program.

6.9.4.2 Washington

The Department of Labor and Industries, charged by the legislature in 1989, has drafted a proposal, Indoor Air Quality in Office Work Environments, to put in place stronger regulation on IAQ. The proposal included: documentation, operation, and maintenance of the HVAC systems; controls for air contaminant sources; evaluation and control of health symptoms related to IAQ; and IAQ during office remodelling. Due to the resistance from the business sector, only the portion which dealt with smoking was enacted in a 1994 law.

6.9.4.3 Florida

Florida has two agencies involved in IAQ. Department of Health and Rehabilitation Services (HRS) is responsible for the anti-smoking legislation. Division of Safety, Florida Department of Labor and Employment Security has developed IAQ Guidelines for non-industrial workplace and recommended exposure ceiling limits. It was empowered in 1994 to review IAQ policy and make a policy recommendation. It was also charged with five tasks analogous to the 1989 bill introduced in Washington. A report on IAQ was submitted in January 1995, but the legislature has not yet responded. Major difficulties include anti-regulatory climate in the business sector, the inconclusiveness of scientific data, and concern for older buildings which may not be able to meet modern standards.

6.9.4.4 New Hampshire

Statutes 10-B (1988), revised in 1995, on Clean Indoor Air in State Buildings requires state-owned or state-leased buildings to meet clean indoor air standards. The New Hampshire Code of Administrative Rules set standards for noise, radon, carbon dioxide, asbestos, and formaldehyde and it adopts ASHRAE standards for ventilation.

6.9.4.5 New Jersey and Utah

PM3006517402

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

The Department of Health and Labor of New Jersey are working on a replacement IAQ standard for the Administrative Code on Indoor Air Quality Standards and Procedures for Building Occupied by Public Employees. Utah enacted a smoking regulation in 1995.

6.9.5 *Difficulties in IAQ Management*

Difficulties encountered in IAQ management in the USA include: i) limited construction budget for ventilation system has affected its design, product and construction; ii) poor maintenance of mechanical systems; and iii) poor communication between management and workers to resolve IAQ problems.

6.10 Hong Kong

6.10.1 *Current situation on IAQ in Hong Kong*

6.10.1.1 The general awareness on IAQ in Hong Kong has increased in the past few years and public discussions on the subject were visible. A number of ordinances and regulations spread over a number of government departments are now in place and indirectly exert some control on indoor air quality even though they may not be designed for the specific purpose (see Section 3). Professionals are confronted by requirements under specific guidelines and Codes of Practice specifically written for the control of IAQ for which they use in their design and other tasks. Recently the Occupational Safety and Health (OS&H) Ordinance was enacted with effect from 23 May, 1997 to include non industrial workplace. As the Ordinance was prepared by the Labour Department (LD), it is intended to cover workplace only. As such, it falls short of providing public health protection in public places. The lack of a specific legislation on the control of IAQ for non industrial premises including public places meant that there is also no enforcement body to take up complaint cases as such in Hong Kong at present.

6.10.2 *Legislation In Hong Kong*

As a result of the lack of a main legislation for IAQ in Hong Kong, there is no systematic approach to IAQ management. Unlike a definitive legislation designed with the intention to translate policy objectives of IAQ into concrete terms for the desired aims, these existing legislations have not incorporated the essential IAQ parameters, nor specify any ambient standards consistent with the requirement to provide IAQ control. As such, the existing legislations can only be classified according to topics as described below.

6.10.2.1 Ventilation Systems

The Building (Planning) Regulations (Cap. 123) B(P)R 30 and 31 specify the requirements for ventilation, specifically natural ventilation, to be provided to every room for habitation, office or kitchen purposes. For offices not complying with B(P)R 31 owing to restrictions in the surrounding environment, B(P)R 34 stipulates that these office premises should be provided with mechanical ventilation capable of supplying fresh air at a rate of not less than 5 changes of air per hour. However, the same does not apply to the other two categories, i.e., habitable rooms or kitchen. If a modification of B(P)R 30 or 31 is granted (in case of offices or kitchens in licensed premises), the Building Authority (BA) may impose a condition for the same mechanical means of ventilation to be provided to his satisfaction. Where a modification of B(P)R 30 or 31 has been granted to allow a deficiency in ventilation to be supplemented by mechanical means, the ventilation equipment must be in position and operational before an Occupation Permit is issued.

Once the ventilation system has been in place, it also requires proper maintenance. Under Building (Ventilation Systems) Regulations (B(VS)R), the owner (not the proprietor) of building has a duty to appoint a registered ventilation contractor to inspect and certify that all dampers, filters and precipitators in such ventilation system are in safe and efficient working order annually.

PM3006517403

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

For Scheduled Premises, which include restaurants, cinemas, theatres, funeral parlours, factory canteen and dancing halls, the requirement for air changes by mechanical ventilation is stipulated under the Public Health and Municipal Services Ordinance (Cap. 132). Such a requirement must be met before an operation license can be granted. However, the legal requirement under B(VS)R which stipulates that the owner of the building has a duty to appoint registered ventilation contractor to ascertain whether or not the dampers, filter and precipitator in the system are in safe working order is not applicable to these Scheduled Premises.

There is a Bill on mechanical ventilation systems currently being drafted by the Electrical and Mechanical Services Department. The requirements on ventilation extend to detailed design criteria to be used on air conditioning systems. The proposal also include maintenance programme as well as the use of qualified personnel for the work.

6.10.2.2 Workplace Control

Under the recently enacted Occupational Safety and Health Ordinance, workplace means any place where employees work (with exceptions, see Part 1, S.3, OS&H Ord.). However, workplaces classified either as factory or industrial undertakings or notifiable workplace will still fall within the power of the Commission for Labour, and the Labour Department shall enforce the Factories and Industrial Undertakings Ordinance (Cap. 59). The proprietor has to provide a healthy and safe place of work to its employees under the general duties clause as well as provisions under various regulations (such as the Dangerous Substance Regulation). The occupational hygiene standards used in these workplaces, namely the Occupational Exposure Limits (OEL), specify the maximum level of air pollutants which workers are allowed to be exposed to in order to protect them from the adverse health effects. There are also subdivisions of such standards into Time-Weighted Average (TWA), Short-Term Exposure Level (STEL), and ceiling level. These occupational exposure levels are applicable to workers in the above classified workplaces except for office workers which come under OS&H Ordinance.

The Occupational Safety and Health Ordinance prepared by the Labour Department is basically an adoption of the UK Health and Safety at Work Act which covers all employees. It stipulates the responsibility of employers to provide a safe and healthy place of work and covers all workplaces, i.e., including offices. There is provision in the Ordinance for the Commissioner of Labour to serve improvement notices and suspension notice to employers. It also prohibits the employers victimising employees making complaints on health and safety issues. As far as we understand there are eight sets of regulations under the ordinance covering topics such as handling and use of chemicals, use of VDU (video display unit) etc., but indoor air quality control is not included.

6.10.2.3 Health Related

In the span of a few years, Hong Kong has succeeded in the prohibition of all televised advertisement on cigarettes and smoking in public places. Designated "no-smoking' areas are required as stipulated in Smoking (Public Health) Ordinance. According to the Broadcasting Authority Ordinance (Cap. 52 and Cap. 391), a Code of Practice to ban cigarette commercial on television was developed and enforced by Broadcasting Authority. The detrimental effect of environmental tobacco smoke has been greatly reduced as a result of enforcing these Ordinances. Numerous organisations and government bodies are actively involved in the enforcement of the Smoking (Public Health) Ordinance. They include: Television and Licensing Authority, the Commissioner of Police, Urban Services Department and Rural Services Department as well as the Department of Health.

6.10.2.4 Product Related

PM3006517404

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Products which emit toxic/hazardous vapours, gases or radiation will affect indoor air quality. The "Pesticides Ordinance" (Cap. 133) implemented in 1991 controls the import, manufacture, supply and sale of all pesticides in Hong Kong and is enforced under the Agriculture and Fisheries Department (AFD). The Ordinance also controls the inert ingredients in pesticide formulations. Only pesticides which have been registered in Hong Kong may be freely distributed for use locally. However, there is no statutory control on the use of registered pesticide. It appears that it is left to the Hong Kong Pest Control Association and a Code of Practice and a User Manual have recently been published. Another group of hazardous products is the radioactive material. It is more extensively covered by the Radiation Ordinance (Cap. 303) which controls import, use and disposal through a licensing system. Other dangerous substances are controlled under the Dangerous Goods Ordinance (Cap. 295) enforced by the Fire Services Department. The Ordinance requires users of dangerous chemicals to store the substance in approved Dangerous Goods (DG) stores and restricts the amount of storage or usage in the workplace. However, the Ordinance focuses on the safety aspects only and it tends to neglect indoor air quality issues.

On asbestos-containing materials (ACM), there are three separate sets of legislation governing the use and handling of this hazardous material, each covering a different aspect of control. The Asbestos Regulations under the Factories and Industrial Undertakings Ordinance controls the use and manufacture of ACM in the workplace and prohibits the use of blue and brown asbestos. The regulation specifies the requirements to protect workers exposed to asbestos including safety and measures of work practice as well as medical surveillance. The Waste Disposal Ordinance defines the proper procedure to dispose of all types of asbestos under a permit system. The Asbestos Regulations under the Air Pollution Control Ordinance stipulates responsibilities of proprietors of premises to investigate, maintain and remove all ACM under a set of stringently laid out requirements. It also regulates the use of registered consultants, supervisors, laboratories and contractors to carry out work related to ACM. The objective of the regulation is to ensure the occupants of premises and the public in the vicinity of premises where ACM is found, are protected against the exposure to asbestos. This regulation on asbestos is clearly concerned with indoor air quality of premises.

The Consumer Product Safety Ordinance (Cap. 456) controls consumer goods and Customs and Excise Department is responsible for enforcing this Ordinance. It comes under the Policy Bureau, Secretary for Trade and Industry (Trade and Industry Bureau). The above account is summarised in Table 6-1.

6.10.3 *Code of Practice and Guidelines*

Code of Practice and guidelines which are aimed to address specifically the control of IAQ are described below.

6.10.3.1 Interim IAQ Guidelines

In 1994, the Environmental Protection Department (EPD) has recommended interim IAQ guidelines for Hong Kong with reference to the health criteria. The indicators selected included those air pollutants identified by the World Health Organisation (WHO) Working Group Consensus of Concern About Indoor Air Pollutants at 1984 Levels of Knowledge. It is believed that attainment of the recommended guidelines should provide a generally acceptable indoor environment. The recommended interim guidelines are summarised in Table 6-2.

PM3006517405

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 6-1: Summary of Responsibilities of Government Department Relating to Indoor Air Pollution

Department	Related Ordinance/ Regulations	Responsibilities
Buildings Dept./ Fire Services Dept	Building (Ventilating Systems) Regulations, Cap. 123. Building (Planning) Regulation (B(P)R) 30 & 31, (B(P)R) 34.	Approval of building plans and issue of consent before building/street works are allowed to commence. When natural ventilation is inadequate, mechanical ventilation shall be capable of providing 5 air changes per hour but this requiement is waived in lieu of air conditioning. Making it a requirement for inspection and certification of the ventilation systems by registered ventilation contractor (fire dampers, filter & precipitator etc.).
Urban Services Dept (USD)/ Fire Services Dept.	Public Health & Municipal Services Ordinance, Cap. 132	For scheduled premises (i.e. restaurant, cinema, dancing hall), to ensure adequate mechanical ventilation when natural ventilation is not sufficient before granting of operation licence. Maintenance of the ventilation systems, fire dampers, etc.
Health Dept./Commissioner of Police/USD/RSD/ Commissioner of TV & Licensing Authority	Smoking (Public Health) (Amendment) Ordinance, Cap. 371 Code of Practice under Broadcasting Authority Ordinance	Control measures relating to prohibition of advertisements, designated 'No Smoking' areas, 'No Smoking' signs, etc.
Labour Dept.	Factories & Industrial Undertakings Ordinance, Cap. 59 Occupational Safety & Health (OS&H) Ordinance	Control of indoor air pollutants in factories. Ordinance covers all workplace (including office premises, i.e., white collar workers) and that person responsible for the workplace (employer-employee or occupier-persons employed) must ensure that workplace is adequately ventilated by fresh air and kept free of impurities (inc. fumes, dust and disease-causing bacteria).
Electrical and Mechanical Services Dept.	Proposed Mechanical Ventilating Systems Bill	Requirement on ventilation design and maintenance, and use of qualified personnel for the work.
Customs & Excise Dept.	Consumer Goods Safety Ordinance, Cap. 456 Ozone Layer Protection Ordinance, Cap. 403 Air Pollution Control Ord. (APCO), Cap. 311	Control of import of consumer goods (including office equipment & building materials) with focus on product safety and enforcement of import control on ozone- depleting substances & asbestos through import licensing (as authorised by EPD).
Agriculture & Fisheries Dept.	Agricultural Pesticide Ordinance, Cap. 133	Control of import, manufacture, supply & sale (but no control of use of registered pesticides).
Environmental Protection Dept.	Air Pollution Control (Amendment) Ordinance, Cap. 311	Control of asbestos in environment.

PM3006517406

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 6-2 Proposed Interim Indoor Air Quality Guidelines

Pollutants	Interim Indoor Air Quality Guideline
Combustion Gases	
Sulphur dioxide	800 µg/m^3 (1-hour average)
	350 µg/m^3 (24- hour average)
	80 µg/m^3 (annual average)
Nitrogen dioxide	300 µg/m^3 (1-hour average)
	150 µg/m^3 (24-hour average)
	80 µg/m^3 (annual average)
Carbon monoxide	30,000 µg/m^3 (1-hour average)
	10,000 µg/m^3 (8-hour average)
Particulate matter	
Respirable suspended particulates	180 µg/m^3 (24-hour average)
	55 µg/m^3 (annual average)
Lead	1.5 µg/m^3 (3-month average)
Organic Compounds	
Formaldehyde	100 µg/m^3 (1-hour average)
Dichloromethane	300 µg/m^3 (1-hour average)
Trichloromethane	60 µg/m^3 (1-hour average)
Trichloroethene	300 µg/m^3 (1-hour average)
Tetrachloroethene	8,000 µg/m^3 (1-hour average)
1,4-dichlorobenzene	730 µg/m^3 (1-hour average)
Benzene	110 µg/m^3 (1-hour average)
	0.12 µg/m^3 (annual average)
Toluene	600 µg/m^3 (1-hour average)
Polynuclear aromatic hydrocarbons	
Benzo[a]pyrene	0.4 µg/m^3 (1-hour average)
Microbial contaminants	1,000 cfu/m^3 (1-hour average)
Radon	200 Bq/m^3 (annual average)

Source: EPD, 1994

In setting the guidelines, the following criteria were used:

(i) for non-carcinogenic air pollutants, the concentration should not be higher than the odour threshold and/or any health concerned concentration;

(ii) for potentially carcinogenic air pollutants, the concentration should not be higher than a level that would give rise to a life time risk of 1 x 10^{-6};

(iii) the proposed standard should be comparable to the Technical Memorandum and/or standards established by WHO or other advanced countries.

6.10.4 Practice Note for Professional Persons: Control of Air Pollution in Car Parks

The ProPECC Note (PN 2/96) provides guidance on the control of air pollution in car parks including:

PM3006517407

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

- Air quality guidelines required for the protection of public health; and,
- Factors that should be considered in the design and operation of car parks in order to achieve the required air quality.

The Practice Note is now used by architects and engineers in the design of car parks and the same level of compliance are expected in planning or building approval.

6.10.5 *Code of Practice for Energy Efficiency of Air Conditioning Installations*

The Energy Efficiency Advisory Committee (EEAC) was established in 1991 under the Electrical and Mechanical Services Department (EMSD) to advise the Government on long term policy for energy efficiency. One of the major initiatives of the EEAC is to develop a set of Building Energy Codes for the design of energy-efficient buildings and the associated building services installations.

The Code specifies design parameters and control criteria of AC installations and minimum coefficient of performance for AC equipment. As the Code sets out only the minimum standards, designers are encouraged to design AC installations with energy efficiency standards above those quoted in this Code. Although the intake rate of outdoor air contributes to a significant portion in energy consumption in AC installations, requirements on this aspect is not included in the Code. Designers are recommended to incorporate into the design of AC installations the appropriate requirements for outdoor air after taking into account the relevant international recommendations and any other relevant health requirements. This Code applies to all buildings except domestic, medical and industrial buildings and it is for the guidance of engineers, designers and any other party concerned in the AC design in buildings. The consultation period ended on 16 September 1996.

6.10.6 *Code of Practice - Prevention of Legionnaires' Disease in Hong Kong*

Following the outbreak of Legionnaires' disease (LED) in 1985 at Stafford District Hospital, UK, the Prevention of LED Committee was set up in Hong Kong. The Committee was chaired by the EMSD and it comprised members from the Department of Health, Works Bureau, the University of Hong Kong, Chinese University of Hong Kong, Architectural Services Department and Water Supplies Department.

Initially the terms of reference of the Committee were confined to areas of immediate concern, especially on the preventive measures against LED in government hospitals. Since 1987, the recommendations of the Committee have been gradually implemented in government hospitals. A set of the recommendations was also sent to all subverted hospitals and private hospitals in July 1989. In January 1990, a technical guideline was issued to the project design teams and operation and maintenance teams of Government buildings to ensure that they are aware of the issue and to adopt proper attitude and appropriate measures in handling the relevant design, operation and maintenance of engineering plants/equipment.

In March 1994, LED has been listed as a notifiable disease under the Quarantine and Prevention of Disease Ordinance (Cap. 141). Medical Practitioners are required by law to notify the Department of Health the existence of the disease in accordance with "Form 2" of the said Ordinance. In the same year, a code of practice on prevention of LED in Hong Kong was published by the EMSD.

6.10.7 *Hong Kong Building Environmental Assessment Method (HKBEAM)*

PM3006517408

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

The Hong Kong Building Environmental Assessment Method for new offices (HKBEAM 1/96) was modelled on the Building Research Establishment Environmental Assessment Method Version 1, but modified to take into consideration of circumstances particular to Hong Kong. It is developed by the Real Estate Developers Association of Hong Kong with the assistance of the Department of Building Services Engineering, Hong Kong Polytechnic University, and the Welsh School of Architecture, University of Wales, Cardiff, UK. It has been developed to set criteria for good environmental performance in buildings and such performance would be recognised in the market place through an independently issued certificate.

HKBEAM 1/96 sought to minimise the adverse effects of new air-conditioned offices in the global and local environment, and at the same time promoting a healthy indoor environment. Its main objectives are:

- to encourage designers and the specifiers to become more environmentally sensitive;
- to enable developers, designers and users to respond to a demand for buildings which minimise adverse effects to the environment, and hence to stimulate such a market;
- to raise awareness on the extent of adverse impact which buildings may contribute to global warming, acid rain and the depletion of the ozone layer;
- to reduce the long term impact buildings have on the environment;
- to set targets and standards which are independently assessed and so help to minimise false claims or distortions;
- to reduce the use of increasingly scarce resources such as water, fossil fuels and non-sustainable timber;
- to promote and encourage energy efficient buildings, building services systems and equipment; and
- to improve the quality of the indoor environment of buildings and hence the health and well-being of their occupants.

The assessment, which was carried out at the design stage, was based on readily available and generally accepted information. The method to conduct assessment has been identified and designs where specific targets are met will be credited. It is not expected that designs will meet all of the target requirements. Meeting one or more of the objectives means that the building is likely to be environmentally better than buildings where the issues have not been addressed.

6.10.8 Current Enforcement Systems

6.10.8.1 Ventilation Design

For all mechanically ventilated premises, their design is controlled by the respective departments through permitting systems in the process of approval of building plans or annual renewal of licences. The Buildings Department, the Urban Services Department and the Fire Services Department are currently participating in the approval processes related to building ventilation which to a certain extent would affect the indoor air quality.

6.10.8.2 EMSD: Implementation and Maintenance of Ventilation Systems

The EMSD takes up a more direct role in managing the indoor environment of Government buildings in that it designs and supervises the installation and maintains all the air conditioning systems. In addition it has also implemented a programme to monitor regularly

PM3006517409

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

the indoor air quality in all the government buildings. So far over 500 premises had been measured. Their main concern is the temperature, humidity, carbon dioxide, dust level, and bacteria level in these premises and that these measurements serve as good indicators on the effectiveness of the air-conditioning systems. With the recent approval of the trading fund, EMSD's services on air-conditioning and indoor air monitoring could be extended to the private sector.

6.10.8.3 Industrial Workplace

The indoor environment of factories and industrial undertakings is under the jurisdiction of the Labour Department which has to assess the close relationship between work processes and workers' well being. The "workplace" is gradually extending to the service industries such as restaurants. Currently they have about eight occupational hygienists measuring airborne pollutants in the factories as well as looking into other physical parameters at work such as ergonomics, lighting and noise. In the past decade, there were prosecutions of cases as a result of large scale accidents involving release of toxic gas. They were all invariably related to accidents rather than long term exposures.

6.10.8.4 Domestic Premises

On domestic premises, both the US and UK had conducted extensive studies on the indoor air quality of homes and had identified significant factors such as ventilation and building materials which affect the air quality. For Hong Kong, it may be appropriate to conduct a small scale study to see if the situation is similar to our western counterparts or otherwise. In any case, the public should be educated on the importance of maintaining good practice related to indoor air quality. The government can promote and educate the public through the media (by Announcement of Public Interest) and distribution of pamphlets on the subject, emphasising the importance of maintaining a healthy indoor environment and practical ways of achieving the goals in their own homes.

6.10.8.5 Environmental Protection Department: Control of Indoor Air Quality

The Environmental Protection Department is responsible for all pollution prevention and control measures, enforcing environmental legislation, monitoring environmental quality, advising on the environmental implication of zoning plans, large industrial plants and all developments or new policies. In the area of indoor air quality, EPD has taken on the role to provide guidance on the control of air quality in car parks through Practice Note. Air quality guidelines include the specification of the maximum concentration limits for two air pollutants deemed most relevant to provide adequate protection to public health (i.e., carbon monoxide and nitrogen dioxide). EPD has also taken up an in-depth study on radon in the indoor environment of homes and offices in Hong Kong. Complaints on poor indoor air quality were followed up by EPD on a case by case basis and priority is given to cases affecting public interest.

From the data of the Radon Study conducted by EPD, the problem of radon in indoor environment in Hong Kong can be controlled with proper ventilation and wise choice of building materials. The consultants at this stage do not consider legislation is warranted on the control of radon in indoor environment, rather education and publicity to the professionals using ProPECC notes and to the public by means of information distribution would suffice.

Specifically, EPD controls the exposure to asbestos fibre in indoor premises. It utilises the system of registered consultants, supervisors, laboratories and contractors to exercise its control via such trained and certified bodies. EPD maintains a team of officers and inspectors who will vet all application for permission to remove asbestos, conduct periodic

PM3006517410

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

visits to such work sites as well as monitor scheduled premises where asbestos investigations and management's plans are required to be drawn up by the registered consultants.

6.10.9 *Summary*

The three tables: Table 6-3 to Table 6-5 summarise the various situation in the eight countries studied and the respective standards they use.

6.11 Conclusion

Useful information on other country's experience has been collated. It forms a basis whereby a strategy for Hong Kong is designed. This is further elaborated in Chapter 8.

PM3006517411

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 6-3 IAQ Related Legislation and Codes Adopted in Eight Countries Studied

Country	IAQ Related Legislation	Codes & Guidelines	Remarks
Australia	Occupational Health and Safety Act 1983, NSW Occupational Health and Safety Act 1985, Victoria Workplace Health and Safety Act 1995, Queensland Public Health Act 1991, NSW Smoke-free Areas (Enclosed Public Places) Act 1994, Australian Capital Territory	For Workplace: "Exposure Standards for Atmospheric Contaminants in the Occupational Environment": Guidance Note [NOHSC:3008(1995)] National Exposure Standards[NOHSC:1003(1995)] For Public Place: "Goals for Maximum Permissible Levels of Pollutants in Indoor Air (interim IAQ goals)" "Managing Indoor Air Quality" (voluntary code of conduct for building owners and managers) Standards Australia: AS1668.2:1991 The use of mechanical ventilation and air-conditioning in buildings Part 2: Mechanical ventilation for acceptable indoor-air quality HB 32-1992 Control of microbial growth in air-handling and water systems in buildings AS3666:1995 Air-handling and water systems of buildings - microbial control Part 1: Design, installation and commissioning and Part 2: Operation and maintenance NHMRC (1988) Australian guidelines for the control of Legionella and Legionnaires' disease NSW Health Department (1991) code of Practice for the control of Legionnaires' disease NHMRC (1991) Interim national indoor air quality goals Worksafe (1995) Exposure standards for atmospheric contaminants in the occupational environment Worksafe (1994) Guidance note on passive smoking in the workplace BOMA Managing Indoor Air Quality Australian Uniform Building Regulations Co-ordination Council, The Building Code of Australia Codes of Practices and Guidance Documents on Thermal	Interim IAQ Goals are not used in the workplace Admit grey area between workplace and public place

PM3006517412

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Country	IAQ Related Legislation	Codes & Guidelines	Remarks
		Comfort	
Canada	Canada Occupational Safety and Health Regulation (Amendment), gazetted March 30, 1996 • every HVAC system installed on or after 1 January 1996, shall adopt AEHRAE Standard 62-1989, as amended from time to time • investigation procedure shall adopt 93-EHD-166 published by Department of Health & Welfare	Exposure Guidelines for Residential Indoor Quality (Revised 1989) Indoor Air Quality in Office Buildings: a Technical Guide 1995 (93-EHD-166) Office Air: A Worker's Guide to Air Quality in Offices, Schools, and Hospitals (Revised 1995) Fungal Contamination of Public Buildings: A Guide to Recognition and Management 1995 National Building Code (1990) Part 6: Heating, Ventilating and Air-Conditioning Part II of Canada Labour Code Some ASHRAE, AIHA and ACGIH standards, such as ASHRAE Standard 62-1989 and 55-1992 Canada Mortgage and Housing Corporation, VOC emission standards and guide to low-emitting materials	TLVs used in industrial hygiene as guidelines or recommandations in controlling potential health hazards only
Japan	Law for Maintenance of Sanitation in Building Ministerial Ordinance of Sanitation in Buildings Ministerial Ordinance of Sanitation in Offices	Building Sanitation Management Standards Air quality guidelines for VOC in indoor ari, WHO Guidebook for Execution and Supervisory of Mechanical Equipment Work Common Specification of Mechanical Equipment Work Standard Chart of Mechanical Equipment Work Guideline for Prevention of Legionnaire Disease	
South Korea	Public Sanitary Law Food Sanitary Law Public Health Law (under Ministry of Health & Walfare) Architecture and Construction Law Road Law Control of Air Quality in Underground Parking Spaces (Under Ministry of Environment) to be legislated The proposed Indoor Air Quality Management Law	IAQ standards for public places (under Law of Public Health): office building (≥3000m^2), complex building (≥2000m^2) theatre (≥1000 seats), education institute (≥2000 m^2) wedding hall (≥2000m^2), gymnasium (≥1000 seats) Air quality guidelines for underground spaces - subway stations and underground shopping arcades	OELs not apply for office building
Singapore	Building Control Act 1989 Factories Act	Code of Practice for the Control of Legionella Bacteria in Air Conditioning Cooling Towers in Singapore	

PM3006517413

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Country	IAQ Related Legislation	Codes & Guidelines	Remarks
		Guidelines for Good Indoor Air Quality in Office Premises Singapore Standard Code of Practice for Mechanical Ventilation and Air-conditioning in Buildings (SS CP13)	
Sweden	Ordinance SFS 1991:1273 Ventilation and Air Quality Ordinance (ASF 1993:5)	The National Board of Occupational Safety and Health, Advice on the Application of the Ordinance ASF 1993:5 NBHBP Norms for Evacuated Air Standards for a number of air pollutants Code of Practice in Ventilation Air Duct Cleaning	CO2 of 1000 ppm is used as indicator.
UK	Health and Safety at Work Act 1974 Workplace Health Safety and Welfare Regulations 1992 Offices, Shops and Railway Premises Act 1963 Building Regulations 1991, Building Act 1985 EU Construction Products Directive (89/106/EEC) Control of Substances Hazardous to Health Regulations (COSHH) (1994)	CIBSE, Guide Vol.A:Design Data 1986 CIBSE, Guide Vol.B: Installation and Equipment Data 1986 CIBSE, Commissioning Code CCA: Air Distribution Systems 1971 CIBSE, Maintenance Management for Building Services 1994 CIBSE, Ventilation Systems Hygiene 1995 HVCA, Standard Maintenance Specifications: Vol.1 Heating and Pipework Systems 1990; Vol.2 Ventilating and Air Conditioning 1991 HSE, How to Deal with SBS, Guidance for employers, building owners and building managers, 1995 HSE, Passive Smoking At Work British Standards: BS 5720:1979 Codes of Practice for Mechanical Ventilation and Air Conditioning in Buildings BS 8210:1986 British Standard Guide to Building Maintenance Management BS 5250:1989 British Standard Code of Practice for Control of Condensation in Buildings BS 5925:1991 Code of Practice for Ventilation Principles and Designing for Natural Ventilation BS EN779:1993 Particulate Air Filters for General Ventilation - Requirements, Testing, Marking	All Health and Safety Regulation apply to all work places. Industrial area enforced by HSE, and offices by LGO of Environmental Health Department. One civil case on passive smoking recorded.
USA	Federal Level IAQ Bill Proposed by OSHA,	Building Air Quality: A Guide for Building Owners and Facility Managers (ISBN 0-16-035919-8), Dec 1991	Not to use OSHA's PELs in

PM3006517414

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Country	IAQ Related Legislation	Codes & Guidelines	Remarks
	Occupational Standard for IAQ Polluntants Proposed by OSHA State Level California: State Law AB13 on prohibition of smoking in the workplace Florida: Statute 386 on anti-smoking New Hampshire: Statutes Annotated 10-B (1988) on clean indoor air in state buildings New Jersey: Indoor air rules proposed Utah: Utach Indoor Clean Air Act 1995 Washington:Ventilation and Indoor Air Quality Code (Chapter 51-13 WAC)	Indoor Air Quality- Tools for School Action Kit (EPA 402-K-95-001) Sept 1995 EPA Research Studies and IAQ Programs EPA's Air Energy Engineering Research Laboratory: Indoor Emission Standard ASHRAE Standard 62:1989, "Ventilation for Acceptable Indoor Air Quality" ASHRAE Standard 55-1992, "Thermal Environmental Condition for Human Occupancy" Protocol for the start-up of cooling towers, an emergency decontamination protocol, general guidelines for routine maintenance of cooling towers Guideline for Prevention of Nosocomial Pneumonia 1994 OSHA Respiratory protection regulations OSHA General Duty Clause California: IAQ Guideline No 1 & 2, Minimum Ventilation Standard Florida; IAQ Guidelines New Hampshire: Code of Administrative Rules He-P 1804 (1990) New Jersey: IAQ standards and procedures for buildings occupied by public employees drafted	non-industrial setting; general duty clause used instead

Note: The information presented is gathered from the reports of the sub-consultants.
The information does not necessarily cover all the IAQ related regulations in each country.

PM3006517415

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 6-4 Summary on IAQ Standards/Guidelines (Maximum Levels)

Item	Australia[1]	Canada[2]	Japan	South Korea	Singapore	Sweden	UK[3]	USA[4] Florida	Hong Kong IAQ-O [5]
Carbon monoxide	9 ppm	9 ppm	10 ppm	10 ppm	9 ppm	2 ppm	50 ppm	10 ppm	8,000 $\mu g/m^3$
Carbon dioxide	1,000 ppm	1,000 ppm	1,000 ppm	1,000 ppm	1,000 ppm	1,000 ppm	5,000 ppm	2,000 ppm	1,000 ppm
RSP		150$\mu g/m^3$	0.15 mg/m^3					150 $\mu g/m^3$ [6]	180 $\mu g/m^3$
TSP	90 mg/m^3			0.15 mg/m^3					
Radon	200 Bq/m^3					200 Bq/m^3			200 Bq/m^3
Formaldehyde	0.1ppm	0.1 ppm			0.01 ppm	2 ppm			100 $\mu g/m^3$
Nitrogen oxide			0.04-0.06 ppm						
Nitrogen dioxide							3 ppm		150 $\mu g/m^3$
Ozone	0.12 ppm		0.06 ppm		0.05 ppm		0.1 ppm		120 $\mu g/m^3$
VOC						0.05-1.3mg/m^3			
TVOC	500mg/m^3	1 & 5 mg/m^3 [7]	300 mg/m^3					5000$\mu g/m^3$ [8]	600 $\mu g/m^3$
Temperature		floor/ceiling <3 °C	17-28 °C	17-28 °C	22.5-25.5 °C				20 - 24 °C & 23 - 26 °C
Relative humidity		25-60% [9]	40-70%	40-70%	70%			65%	30 - 60%
Air velocity		0.15 - 0.25 m/s [10]	0.5 m/sec	0.5 m/sec	0.25 m/sec				0.25 m/sec
Illumination				100 lux					

[1] Interim National Indoor Air Quality Goals recommended by NHMRC
[2] Make reference to ASHRAE, AIHA and ACGIH standards, and Air Quality in Office Buildings : A Technical Guide 1995
[3] Occupational Exposure Limits - long term exposure (8-h TWA period)
[4] ASHRAE standards can be filled in instead
[5] As the Standard Class recommended by the Consultants in this IAQ study.
[6] ASHRAE indoor exposure guideline (24-hr average)
[7] Proposal for target & action units respectively
[8] Environmental Health & Engineering, Inc.
[9] ASHRAE
[10] 0.15 m/s winter & 0.25 m/s summer

PM3006517416

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 6-5 Summary On Ventilation Standards/Guidelines

Item	Australia[1]	Canada[2]	Japan	South Korea	Singapore	Sweden	UK	USA[3]	Hong Kong
Openable windows (% of floor area)		5% (in some provinces)	5%				5% (non-domestic	5% (California)	
Min air flow (per person) top: moderate amount of smoking bottom: smoking lounge		7.5 l/s (in some provinces)				20 l/s (s) (meeting rm and shops)	8 l/s (ns) 32 l/s (s)	10 l/s (ns) 30 l/s (s) (ASHRAE)	
Air flow rates	10 - 15 L/s person		15m^3/hr/ m^2				0.1-0.15m/s		
Air changes				10/hr (underground parking)	0.4/hr	0.5/hr or 4 l/s/person			5 /hr
Min fresh air supply rates for air conditioning spaces (smoking area) (per person)					1.1m^3/hr /m^2 floor 13 m^3/hr (office)		5 l/s (shops) 8 l/s (offices)		

[1] Australia Standard AS 1668.2
[2] Make reference to ASHRAE, AIHA and ACGIH standards, and Air Quality in Office Buildings : A Technical Guide 1995
[3] ASHRAE Ventilation Standards are generally adopted in the USA.

PM3006517417

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

7. PRODUCTS/TOOLS OF THE CONSULTANCY

7.1 Introduction

7.1.1 This chapter gives a brief description of the tools which have been delivered as part of the requirements of the consultancy. They include an extensive database in electronic form, a human exposure model (IAQSim v1.0), an exploration on technical mitigation measures and finally a Code of Practice on indoor air quality.

7.2 Database

7.2.1 Two sets of database were submitted to EPD containing all data obtained in the study for future reference, manipulation and expansion.

7.2.2 The target users of this system include those with responsibility on public health, surveyors and planners and policy makers in general. They can input the survey data directly, analyse, and draw conclusions from the data. From the point of view of the users, the database system should be portable, user friendly, and provide all the input fields of an IAQ study. At the same time, the planner's point of view, the database system should be able to handle a large capacity of data, provide a multi-dimensional query system, generate report and to have database protection, remote access from workstation and data sharing with other systems. In order to achieve all the above criteria, two systems have been produced in succession. One is a database system operating on the Microsoft Access database system which is easy to use and facilitates input of raw data collected, while the other on SQL client-server system is designed to improve the collation abilities.

7.2.3 *Microsoft Access Database System*

7.2.3.1 The Microsoft Access database system has the advantage of being economical and it is also widely available. It has a relatively small but sufficient memory capacity to handle all the required data in a survey. This has also allowed it to be portable which provides a high degree of convenience in site surveys.

7.2.3.2 The database has been designed as a questionnaire format which would be welcomed by surveys because of its "user-friendliness". The database also provides a standard report output format which can be used for data comparison purpose. It provides all the necessary fields to store the data from the survey although some data are for reference only. The relatively small size of the database allows the data from each survey to be recorded directly into the database. It has made backup and restoration easy, and it also allows wide distribution as it can be used in even a notebook computer. It is a convenient tool for the surveyor to enter data on-site.

7.2.4 *SQL Database*

7.2.4.1 The ultimate database to be used is the SQL database which is a scaleable, high-performance database management system designed to meet the requirements of client-server computer systems. It is integrated with Microsoft Windows NT threading and scheduling services, performance monitor, event viewer, and a security system. It provides a windows-based management interface with visual drag-and-drop control over multiple servers for remote management of data replication, server administration, diagnostics, and tuning.

7.2.4.2 Its Client-Server based system nature allows multiple access to the database from different clients. Workstation workload is reduced by the introduction of SQL server processing, thus

PM3006517418

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

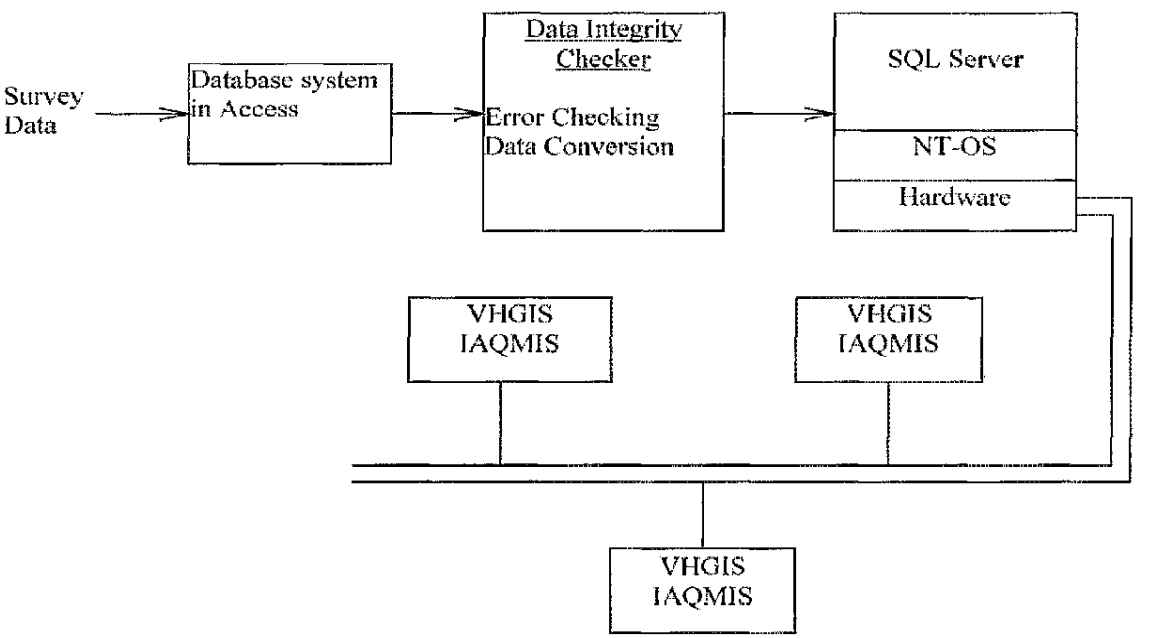
resulting in a fast query system. In co-operation with VHGIS, a graphical query system is also provided which allows basemap import, district selection, and /or building selection. It provides data protection, integrity check and security. An illustration on the SQL database is contained in Appendix IX-1.

7.2.5 *Inter-Linking of Two Systems*

7.2.5.1 The database system running on Access acts as a primary storing system to store all the site survey data. Not all the data from the Access database are required in the SQL database system, a Data Integrity Checker is important as an intermediate link between the two systems to sort out the required information. All the query data are then sorted in the database on SQL server. Workstations installed with an IAQMIS on VHGIS platform are able to concurrently utilize information generated from the SQL server, thus creating a multi-user environment.

Figure 7-1 illustrates the overall structure of the database system.

Figure 7-1 Structure Diagram of the Database System



7.3 Human Exposure Assessment Model

7.3.1 In this study, the human exposure assessment model (IAQSim v1.0) is submitted as a computer software. The extent of exposure is based on the working life of an office worker under certain working condition through the route of inhalation only. Since health risk assessment is a much more complicated process which involves intricate epidemiological studies and human physiology, they are outside the scope of this study. This task is simplified to give a human exposure index which can be useful as a tool in assessing the impact of indoor air pollution on its occupancy on a comparative basis rather than as absolute values and allows user to set priority when mitigating or improving their indoor environment.

PM3006517419
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 6-2 Proposed Interim Indoor Air Quality Guidelines

Pollutants	Interim Indoor Air Quality Guideline
Combustion Gases	
Sulphur dioxide	800 $\mu g/m^3$ (1-hour average)
	350 $\mu g/m^3$ (24- hour average)
	80 $\mu g/m^3$ (annual average)
Nitrogen dioxide	300 $\mu g/m^3$ (1-hour average)
	150 $\mu g/m^3$ (24-hour average)
	80 $\mu g/m^3$ (annual average)
Carbon monoxide	30,000 $\mu g/m^3$ (1-hour average)
	10,000 $\mu g/m^3$ (8-hour average)
Particulate matter	
Respirable suspended particulates	180 $\mu g/m^3$ (24-hour average)
	55 $\mu g/m^3$ (annual average)
Lead	1.5 $\mu g/m^3$ (3-month average)
Organic Compounds	
Formaldehyde	100 $\mu g/m^3$ (1-hour average)
Dichloromethane	300 $\mu g/m^3$ (1-hour average)
Trichloromethane	60 $\mu g/m^3$ (1-hour average)
Trichloroethene	300 $\mu g/m^3$ (1-hour average)
Tetrachloroethene	8,000 $\mu g/m^3$ (1-hour average)
1,4-dichlorobenzene	730 $\mu g/m^3$ (1-hour average)
Benzene	110 $\mu g/m^3$ (1-hour average)
	0.12 $\mu g/m^3$ (annual average)
Toluene	600 $\mu g/m^3$ (1-hour average)
Polynuclear aromatic hydrocarbons	
Benzo[a]pyrene	0.4 $\mu g/m^3$ (1-hour average)
Microbial contaminants	1,000 cfu/m^3 (1-hour average)
Radon	200 Bq/m^3 (annual average)

Source: EPD, 1994

In setting the guidelines, the following criteria were used:

(i) for non-carcinogenic air pollutants, the concentration should not be higher than the odour threshold and/or any health concerned concentration;

(ii) for potentially carcinogenic air pollutants, the concentration should not be higher than a level that would give rise to a life time risk of 1×10^{-6};

(iii) the proposed standard should be comparable to the Technical Memorandum and/or standards established by WHO or other advanced countries.

6.10.4 Practice Note for Professional Persons: Control of Air Pollution in Car Parks

The ProPECC Note (PN 2/96) provides guidance on the control of air pollution in car parks including:

PM3006517407

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

7.3.3.7 The pressure in the room is the area-weighted average of the pressures in the surrounding rooms. However, in the model, the assumption is relaxed in order to shorten computer memory, instead, the following assumptions are built into the model:

i. Ambient pressure is everywhere equal to zero.

ii. The HVAC fan delivers a fixed quantity of air, independent of pressure.

iii. The HVAC return ducts collect a fixed quantity of air, equal to the air delivered minus the makeup air.

iv. A quantity of air equal to the makeup air flows into or out of the building through windows or other openings to the outside.

v. There are no pressure drops along the supply and return.

7.3.3.8 These assumptions ensure global conservation of mass. The relaxation solution moves toward mass conservation on a room-by-room basis. The pressure independence of HVAC delivery and return flows is only approximately correct.

7.3.3.9 In summary, the model begins the solution process by assuming each room is at zero pressure (outside pressure). The person then calculate the flow into the room through the HVAC inlet as a fraction of the total flow. The person then use the flow resistance of the openings to calculate the HVAC supply pressure. The same flow, reduced by the makeup air fraction, is exhausted through the HVAC returns in each room. The flow through the HVAC return openings is then used to calculate the HVAC return pressure and each room is treated separately.

7.3.4 *IAQSim v1.0 (Part 2)*

7.3.4.1 The Part 2 assesses the human exposure levels in the form of a human exposure index as a result of airborne contaminants and the time of exposure during an assumed lifetime work pattern. The data on the airborne concentration can be directly entered into this Part 2 or it can be directly transported from the results of Part 1 simulation.

7.3.4.2 There are two main parts to the index, each calculated on a different basis. The assessment adopted the method published by the CAPCOA[1] (California Air Pollution Control Officers Association, 1993).

7.3.4.3 The categories of risk are termed non-threshold (NT) risk and threshold (TH) risk. The individual exposure pathway considered is that by inhalation alone. The lifetime exposure is based on a 40-hour week, 52 weeks a year for 40 years.

7.3.4.4 For the non threshold (NT) risk, the calculation and classification would follow the methodology developed by CAPCOA on cancer risk and expressed as the excess of the individual's lifetime cancer probability (LCP). The cancer potency for each compound differs and this is expressed as "Unit Risk Factor" (URF) which is a valve derived from an estimate of the upperbound of what may result from exposure to 1 $\mu g/m^3$ of pollutant over a life time. Lifetime in this case is assumed to be 24 hours a day, 365 days for 70 years. For a person working in an office environment, the lifetime factor is changed and a correction factor ("A") based on 8 hours a day, 240 days a year and 46 years is calculated.

$$A = [8/24 \times 240/365 \times 46/70] \quad (1)$$

PM3006517421
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

7.3.4.5 The airborne concentration is taken to be [C] µg /m^3, assumed to be constant throughout the life time, then the life time cancer probability is calculated as:-

$$LCP_i = [C] [URF^i] [A] \quad (2)$$

7.3.4.6 It must be emphasised that the assumptions made here are very wide and assumptions on a constant level of contaminant over so many years may be grossly over estimated. However, the objective is not to quantify risk but to provide a tool which allows premises to be compared in a similar way.

Transcribing equation (2) to the NT risk scenario

$$[NT] = [C] *[URF] \quad (3)$$

comparing this to the no risk level of 10^{-6}, a ratio is obtained: $[NT]/10^{-6}$.

7.3.4.7 The URF list (in $\mu g^{-1}m^{-3}$) has been collated by CAPCOA 1993. Although it is widely used, the calculated URF is very conservative. As a result, the LCP calculated almost invariably is much higher than the 10^{-6} (no risk level). However given the premise that this has been derived, the index would be an appropriate comparison tool. The URF values of the chemicals applicable to the on-site study, e.g., formaldehyde, environmental tobacco smoke (ETS) and five of the volatile organic compounds (VOCs) are adopted from CAPCOA (1993). These values can be directly substituted for use in the calculation of NT risk. Details of the relevant URF values are presented in Appendix X-1.

7.3.5 *Threshold Risk (TH)*

7.3.5.1 Using the methodologies of CAPCOA, reference exposure levels (RELs) are used as indicators of potential adverse health effects. A REL is a concentration level (µg/m^3) at or below which no adverse health effects are anticipated. RELs are designed to protect the most sensitive individuals in the population by the inclusion of a margin of safety. RELs are generally based on the most sensitive adverse health effect reported in the medical and toxicological literature. This means that value which exceeds the REL given does not automatically indicate a health impact.

7.3.5.2 According to CAPCOA (1993), the potential for chronic health effects should be evaluated by comparing the long-term exposure levels of estimated annual average concentration of the chemicals inhaled to the RELs. This involves a simple rationing method.

7.3.5.3 For the inhalation route, RELs are different for "acute" and "chronic" exposures. "Acute RELs" are associated with short-term exposure whereas "chronic RELs" are associated with long-term exposure. In this normal IAQ considerations for non-industrial settings, adverse health effect from acute toxicity is omitted since such occurrence is unlikely and hence ignored.

7.3.5.4 The estimation of chronic health risk is determined by comparing the airborne contaminant concentration [C]µg / m^3 to established health standards. The ratio is referred to as hazard quotient. The chronic hazard quotient for each chemical is calculated by dividing the exposure level by the REL. Appendix X-2 shows the RELs.

Hazard Quotient $(Q)_{chronic} = [C] / REL_{chemcial}$

The hazard quotient is the [TH] (as threshold risk)

PM3006517422
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

7.3.5.5 Some chemicals are known to affect more than one toxicological endpoint. As such, the estimated value (i.e., the hazard quotient) will be applied to these toxicological endpoints concerned. The total hazard quotient is the sum of the relevant hazard quotient for each chemical affecting the same target organ. Thus, the list compiled by CAPCOA (1993) on the substances to be considered in the total hazard quotient for each toxicological endpoint is used as reference (see Appendix X-3 for the list of RELs relevant to the current study).

7.3.5.6 The total hazard quotient reveals that the more intensive the exposure to a particular chemical, the faster the person will reach the toxicity threshold for that chemical so long as the substance affect the same organ or system in the body. From the list of chemicals considered in the IAQ study, it is found that many of them tend to have potential effects on the respiratory and gastro-intestinal system as well as the liver (details as shown in Appendix X-3).

7.3.6 *IAQ Human Exposure Index*

7.3.6.1 The overall Human Exposure Index (I) which serves the purpose of setting priority for improvement in a premise/building is compiled by a combination of i) the lifetime non threshold risk (NT) probability, and ii) the overall (TH) risk for the chemicals concerned. Such an index has to account for the importance of the NT and the TH of exposure to chemicals.

$$I = \sum_{i=1}^{n} (NT_i / 10^{-6}) + \sum_{j=1}^{n} TH_j$$

Where,

I is the Human exposure index
NT = non threshold risk
TH = Threshold risk for a particular target organ.

7.3.6.2 In conventional practice, any value >1 derived from adding individual hazard index from different chemicals affecting the same toxicological endpoint would be considered significant as far as non-cancer risk is concerned.

7.3.6.3 A point to emphasise is that there is a high degree of uncertainty in risk assessment. Lack of data accounts largely for the problem. Therefore, assumptions have to be made. An issue here is the RELs for non cancer health effects. OEHHA (Office of Environmental Health Hazard Assessment) calculated these values and it decided to change the term from "acceptable exposure levels" used previously to "reference exposure levels". The latter is deemed more appropriate. However, in the report by the Toxics Committee of the California Air Pollution Control Officers Association (CAPCOA), Air Toxics "Hot Spots" Programme (CAPCOA 1993), a statement is made to caution reader against using the guidelines to develop RELs independently.

7.3.7 The Computer Mode IAQSim v1.0

The computer software package provides user-friendly interface to allow input of floor plans graphically and defines physical parameters such as windows, doors, partitions, pollution sources and sinks as well as MVAC inlets and outlets etc. of a premises conveniently. The assessment time is adjustable and can be run for a period of 48 hours to see the cumulative

PM3006517423
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

effect of indoor pollutants. The final results are displayed in graphs/ charts and tables to allow easy retrieval and display of results. Excerpts of the software is shown in Appendix XI.

7.3.8 *Summary*

The Human Exposure Model IAQSim v1.0 has been constructed and provides a useful tool for setting priority in buildings according to the potential risk to its occupants. It also provides a tool for architects at design stage to plan for its layout and material used.

7.4 Technical Mitigation Measures

7.4.1 Having identified some of the major problems related to IAQ and the peculiar situations in Hong Kong through this study, an exploration into the possible mitigation measures was conducted with the purpose of specifying the feasible ones in the draft Code of Practice on IAQ.

7.4.2 Mitigation measures can be divided into two main branches : source control and ventilation control. The application of such measures may also differ for new buildings and old buildings. The general principle of reasonable / practicable is fundamental in the selection of mitigation measures while the social economic impact on owners and tenants must also be part of the consideration.

7.4.3 *Planning of New Buildings*

New Buildings would be the first target where effective mitigation measures can be implemented in the most cost effective way. The siting of a building at the planning stage has to take into account the external sources of air pollution due to industrial sources and vehicular emissions. The newly passed Environmental Impact Assessment (EIA) Ordinance requires the assessment of air pollution impact of major projects. The effect the outdoor sources on IAQ has to be demonstrated to show that pollution levels are acceptable. At the project operation stage, extensive environmental monitoring and auditing has to be carried out to ensure the predictions at design stage of potential impacts and their mitigation measures were implemented.

7.4.4 *Outdoor Air*

The impact of outdoor air can be mitigated by careful selection of air intake locations taking into account the prevailing wind directions and local air eddy currents. The use of artificial ventilation with filtration system is likely to be expensive and impractical, hence is considered as last resort.

7.4.5 *Architectural Design*

The architectural design to achieve requirements which are energy-saving can be innovative and should have minimal adverse effect on the environment. The guidelines under HKBEAM (as mentioned in Chapter 6) are to be followed. Building pressurisation, envelope design, control of humidity and temperature etc. should be considered.

7.4.6 *Material Selection*

Emissions from building material are a major source of indoor air quality problem. In new building design or in renovation work, selection of low-emission materials is crucial in providing a good indoor air quality. The details of material emission rates, types of material and usage are presented in Appendix III and in Hong Kong it may not be possible to buy the desired materials at a reasonable price. For example formaldehyde-free plywood is not easy to find. The planning for move-in time to allow the "gassing-out" of these emitting materials would pose less IAQ problems.

PM3006517424
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

7.4.7 *Office Equipment, Furnishing and Stationery*

7.4.7.1 The choice of modern office equipment is diversified in terms of performance quality. Equipment such as photocopying machines have taken giant steps towards improvement of their emission control. The amount of ozone emitted due to the high-voltage light source is minimised while carbon particles from ink have been efficiently filtered off. Nonetheless, the selection of equipment needs to be carefully considered with such criteria in mind. Also the location of equipment is important so that ventilation can play a role in reducing the accumulation of such pollutants in the indoor environment.

7.4.7.2 Materials used in furnishing or partitioning are discussed in the previous section (reference should be made to Appendix III for details).

7.4.7.3 Common stationery used in the office often contains solvents which may increase the volatile organic compound concentrations in the air. Office workers should be made aware of these sources and keep them from evaporating when not in use.

7.4.7.4 Other services: pesticide, asbestos, radon, and bio-contaminants can be controlled through good work practice and housekeeping. Details are in the Code of Practice (see Section 7.5).

7.4.8 *Ventilation Control*

7.4.8.1 Ventilation is identified to be one of the most important factor affecting IAQ. The air-change per hour was found to correlate to occupants satisfaction with the IAQ of their workplace. The mitigation measures related to ventilation are listed out in details in the draft document of ASHRAE on Ventilation for Acceptable Indoor air quality (1997). The details are highlighted in Chapter 8 which goes into detail on ventilation standards air filtration system, maintenance requirements and air duct cleaning under the Code of Practice. There are also recommendation to segregate ventilation systems during renovation works which may affect people sharing the building and to provide extra ventilation for newly renovated buildings to allow exhaust of building contaminants.

7.4.9 *Air Cleaners/Purifier*

There are many products in the market place offering devices to clean up the indoor air using various techniques. These includes filtration & ionization. Filtration include the use of ordinary dust filters, high efficiency particulate air filters (HEPA) and activated charcoal, all are effective to a certain extent in reducing the dust level indoors. The activated charcoal type can also adsorb organic vapours which thus get rid of odour as well. The ionization type effectively attracts the particulates to the air purifier and deposits them by the charges. Ozone is usually produced due to the ionizer. The choice of a correct air purifier for the type of premises, or by its occupancy and activity is a useful means to reduce pollution.

7.5 Code of Practice

7.5.1 The draft Code of Practice for the Management of Indoor Air Quality (CoP) has been endorsed by the IAQ Steering Committee. The primary objective of this CoP is to give background information and practical guidelines to enable users to manage IAQ, and to solve

PM3006517425
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

problems if they arise. The CoP is a voluntary code which applies to all buildings provided with air conditioning (AC) installations for human comfort except domestic, medical, schools and industrial buildings.

7.5.2 The CoP is an important document as it defines the state-of-the-art practice for building owners and professionals, and it also enable the market to manufacture or supply output on how to provide acceptable indoor air quality. The CoP is applicable to premises individuals own, design or manage. The CoP provides a list of IAQ objectives for selected air pollutants forming the performance standards which the premises should achieve.

7.5.3 The CoP defines clearly the responsibilities of building owners, proprietors, managers, authorised, person, registered engineers, manufacturers and suppliers of building related materials, environmental consultants, testing laboratories and tenants/occupants of buildings.

7.5.4 An overall management strategy for building managers in the implementation programme is listed in seven steps :-

Step 1: Allocation of responsibility. Assign a person (IAQ Manager) with sufficient authority and resources and with a detailed knowledge of the building to be in charge of the IAQ in the work place.

Step 2: Preparation. The appointed IAQ Manager should review the CoP and all legislative requirements, identify all activities which could affect the IAQ and formulate appropriate remedial strategies. Provide training to staff within the building management team.

Step 3: Review of work contracts and procedures. The IAQ Manager should institute or revise the procedures and schedules for building and equipment cleaning, maintenance, and renovation work; specify cleaning products, construction materials, furnishings; and define policy on tobacco smoking; as well as the pest control strategies.

Step 4: Review of occupation contracts. The IAQ Manager also needs to define tenants' responsibilities for IAQ and, where appropriate, insert them in occupation leases.

Step 5: Communication. The IAQ Manager should develop, document and communicate policy for special incidents of emission; as well as complaints from the occupants.

Step 6: Investigation of complaints. The IAQ Manager should develop and document procedures for evaluations of investigations and effectiveness of mitigation measures adopted.

Step 7: Record keeping. The IAQ Manager should keep up-to-date records of IAQ complaints and follow-up action, as well as Material Safety Data Sheets (MSDSs) for materials used and stored in the building.

7.5.5 *Setting of standards/objectives for IAQ*

7.5.5.1 The CoP provides also a set of IAQ objectives for Hong Kong such that people working towards achieving an acceptable indoor environment can have clear guidance and standards to follow. There is no available international standards on IAQ which cover the whole range of pollutants of concern, taking into account the different range in exposure time.

7.5.5.2 During the course of the consultancy, extensive literature survey was conducted to collect all available IAQ standards which are scattered throughout building-related guidelines in North America and Europe. The guidelines by WHO is one of the key documents referred to in the design of the IAQ objective due to its universal acceptance. The basis on which WHO draws up the standard is taken into consideration as it has taken into account the extreme conditions of the very old and very young.

PM3006517426
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

7.5.5.3 In addition, the well-established standard for industrial workplace exposure published as TLV by the American Conference of Governmental Industrial Hygienist (ACGIH) is also referred to as the upper bound limit. This TLV has been adopted by both UK and Hong Kong as the basis to set their Occupational Exposure Limits (OEL), although UK has already indicated that they will draw up separate guidelines for indoor air quality (Berry et al., 1996)[2]. The TLVs are standards by which 95% of white Caucasian male industrial workers working a normal week of 40 hours, 5 days a week, can be exposed to day in and day out without adverse impact. These limits are not fine lines between safe and dangerous concentrations nor are they a relative index of toxicity.

7.5.5.4 There are also other well-recognised standards for US, e.g., NIOSH, which tend to be more stringent; other European standards have also published various guidelines, for example, countries such as Sweden and Finland.

7.5.5.5 The approach adopted in designing the "Standard" class IAQ-objective is to use WHO as the lower bound limit and TLV as the upper bound in general. The measured Hong Kong IAQ data in terms of high-low-mean were considered. The proposed objective would be somewhere between WHO and TLV and of a level achievable by 75% of Hong Kong office premises. CO_2 is the only exception where the proposed IAQ objective of 1,000 ppm is lower than the 75% percentile for Hong Kong which is 1,082 ppm. The objective designed this way is attainable and acceptable but not necessarily desirable if one is designing for optimal condition. Appendix XII gives details on the percentile of attainability for the various pollutants.

7.5.5.6 Following the example of Finland, the IAQ objective has two more classes apart from the "Standard" class. The "Standard Plus" and "Premier" class are more stringent, and allows conscientious building owner/management to further improve their IAQ on a voluntary basis.

7.5.5.7 Table 7-1 summarises the recommended IAQ objectives for Hong Kong and their reference to other internationally acceptable standards. For VOC's, very few standards have been published. Table 7-2 shows the IAQ objectives (IAQ-O) for selected VOCs. Four of the VOCs are adopted from WHO guidelines, namely, benzene, toluene, trichloroethylene and tetrachlorothylene and the other IAQ-O were designed as 5% of TLV.

7.6 Conclusion

The products produced by the consultancy allow the prediction of IAQ and human exposure by a computer model, a database for data storage and manipulation, and a Code of Practice giving detailed guidance as to how to achieve acceptable indoor air quality in buildings and is recommended to be adopted by professionals in building design, maintenance and management.

PM3006517427

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 7-1 Recommended Indoor Air Quality (IAQ) Objectives for Hong Kong

		Office Buildings (8-hr average)			Public Places	
	Unit	Premier Class	Standard Plus Class	Standard Class	1-hr average	8-hr average
Room temperature, winter	°C	22-23 [a,b]	21-23 [a,b]	20-24 [a,b]	---	---
Room temperature, summer	°C	23-24 [a,b]	23-25 [a,b]	25-26 [a,b]	---	---
Vertical temperature difference	°C	< 2 [c]	< 3 [c]	< 4 [c]	---	---
Relative Humidity	%	40-60 [a]	40-60 [a]	40-60 [a]	---	---
Air Movement	m/s	<0.15 [c]	< 0.20 [c]	< 0.25 [c,d]	---	---
Carbon Dioxide (CO_2)	*ppm*	< 800 [e]	< 1,000 [d]	< 1,000 [d]	---	< 1,000 [d]
Carbon Monoxide (CO)	$\mu g/m^3$	< 2,000 [e]	< 5,000 [e]	< 10,000 [f,i]	< 30,000 [f,i]	< 10,000 [f,i]
Respirable Suspended Particulates (RSP)	$\mu g/m^3$	< 20 [c]	< 100	< 180 [i]	---	< 180 [i]
Nitrogen Dioxide (NO_2)	$\mu g/m^3$	< 50 [f]	< 100	< 150 [i]	< 200 [f]	< 50 [f]
Ozone (O_3)	$\mu g/m^3$	< 50 [c]	< 70 [c]	< 120 [f]	< 240 [i]	< 120 [f]
Formaldehyde (HCHO)	$\mu g/m^3$	< 30 [c]	< 50 [c]	< 100 [h]	< 100 [h]	< 50 [e]
Total Volatile Organic Compounds (TVOC)	$\mu g/m^3$	< 200 [c,e]	< 300 [c,g]	< 600 [c]	< 300 [g]	< 200 [e]
Nicotine	$\mu g/m^3$	Segregated smoking area should be provided		< 6.8 [j]	---	< 6.8 [j]
Radon (Rn)	Bq/m^3	< 200 [c,k]	< 200 [c,k]	< 200 [c,k]	< 200 [c,k]	< 200 [c,k]
Noise Level of MVAC equipment	NC	35 [l]	40 [l]	45 [l]	45 [l]	45 [l]
Airborne Bacteria	cfu/m^3	500 [m]	500 [m]	1,000 [m]	---	1,000 [m]
Airborne Fungi	cfu/m^3	500 [m]	500 [m]	500 [m]	---	500 [m]

a ASHRAE 55-1992, (1992), Thermal Environmental Conditions for Human Occupancy
b Energy Efficiency Advisory Committee, (1997), Code of Practice for Energy Efficiency of Air Conditioning Installations
c FiSIAQ. (1995), Classification of Indoor Climate, Construction, and Finishing Materials
d ASHRAE 62-1989R, (1996), Ventilation for Acceptable Indoor Air Quality (current status of the revised Standard has been "on hold" since July, 1997)
e USEPA, (1996), Maximum Allowable Air Concentration Standards for EPA Buildings
f WHO, (1994), Update and Revision of the Air Quality Guidelines for Europe
g WHO, (1989), Indoor Air Quality : Organic Pollutants
h WHO (1995), Updating & Revision of the "Air Quality Guidelines for Europe". WHO recommended the use of a lower concentration (not exceeding 0.01 mg/m^3 as a 30-min average) for those who show hypersensitivity reactions.
i EPD, (1987), Hong Kong Air Quality Objectives under the Air Pollution Control Ordinance (Cap. 311)
j OSHA, (1995), OSHA General Industry Air Contaminants Standard
k EPD, (1995), Radon and You
l ASHRAE, (1996), ASHRAE Handbook : HVAC Systems and Equipment
m ACGIH, (1995), Air Sampling Instruments for Evaluation of Atmospheric Contaminants (100 - 1,000 cfu/m^3 = intermediate e.g. general indoor and outdoor concentrations)

Table 7-2 Indoor Air Quality Objectives for Individual VOCs

IAQ Objectives

PM3006517428

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

COMPOUND	1-Hour Average	8-Hours Average	Odour Threshold [f]	IARC Classification
Benzene	5 ppb (16.1 µg/m^3)[a]	5 ppb (16.1 µg/m^3)[a,b]	12 ppm (39 mg/m^3)	1[3]
Formaldehyde	90 ppb (100 µg/m^3)[a,g]	90 ppb (100 µg/m^3) [a,g]	0.83 ppm (1.04 mg/m^3)	2A[4]
Carbon tetrachloride	16 ppb (103 µg/m^3)[d]	16 ppb (103 µg/m^3)[c]	96 ppm (613 mg/m^3)	2B[5]
Trichloroethylene	143 ppb (770 µg/m^3) [d]	143 ppb (770 µg/m^3) [a,b]	28 ppm (153 mg/m^3)	2A[6]
Tetrachloroethylene	37 ppb (250 µg/m^3) [d]	37 ppb (250 µg/m^3)[a,h]	27 ppm (186 mg/m^3)	2A[7]
Chloroform	33 ppb (163 µg/m^3) [d]	33 ppb (163 µg/m^3)[c]	85 ppm (422 mg/m^3)	2B[8]
1,2 (1,3) -Dichlorobenzene	300 ppb (1,830 µg/m^3) [e]	83 ppb (500 µg/m^3)[c]	0.30 ppm (1.83 mg/m^3)	Inadequate Data[9]
1,4-Dichlorobenzene	180 ppb (1,100 µg/m^3) [e]	33 ppb (200 µg/m^3)[c]	0.18 ppm (1.1 mg/m^3)	Inadequate Data[10]
Ethylbenzene	2,300 ppb (10 mg/m^3) [e]	338 ppb (1,447µg/m^3)[c]	2.3 ppm (10 mg/m^3)	Not Classified
Toluene	290 ppb (1,092 µg/m^3)	290 ppb (1,092µg/m^3)[a]	2.9 ppm (11.11mg/m^3)[a]	3[11]
Xylenes	1,100 ppb (4.85 mg/m^3) [e]	338 ppb (1,447µg/m^3)[c]	1.1 ppm (4.85 mg/m^3)	3[12]

Abbreviations :

a WHO, Updating & Revision of the *Indoor Air Quality Guidelines for Europe* (1995)
b "Risk level where very few would consider action necessary, unless clear causal risk with consumer products", The Royal Society, London (1983
c 1/300 of ACGIH TLV-TWA, *ACGIH Threshold Limit Values for Chemical Substances and Physical Agents* (1996)
d 1-hour average objective = 8-hour average objective as the VOC is classified as Group1 or 2 compound under the IARC
e 1-hour average objective = odour threshold
f AIHA, *Odour Thresholds for Chemicals with Established Occupational Health Standards* (1993)
g Standard Class IAQ-objective; a 30-minute average exposure limit as recommended by WHO
h A continuous exposure limit as recommended by WHO

International Agency for Research on Cancer (IARC) Classifications :

Group 1 : The agent is carcinogenic to humans (sufficient evidence of carcinogenicity in humans).
Group 2A: The agent is probably carcinogenic to humans (limited evidence of carcinogenicity in humans and sufficient evidence in experimental animals).
Group 2B: The agent is possibly carcinogenic to humans (inadequate evidence of carcinogenicity in humans but sufficient evidence in animals)
Group 3 : The agent cannot be classified as to its carcinogenicity to humans.
Group 4 : The agent is probably not carcinogenic to humans (evidence suggesting a lack of carcinogenicity in animals).

PM3006517429

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

1 CAPCOA, 1993. Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines, Prepared by the Toxics Committee of the California Air Pollution Control Officers Association (CAPCOA), Oct., 1993.

2 Berry, R.W., Brown, V.M., Coward, S.K.D., Crump, D.R., Gavin, M., Grimes, C.P., Higham, D.F., Hull, A.V., Hunter, C.A., Jeffery I.G., Lea, R.G., Llewellyn, J.W., Raw, G.J. 1996. Indoor Air Quality in Homes, Part I, The Building Research Establishment Indoor Environment Study, Watford, Construction Research Communications Ltd.

3 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol.,29, 1982, pp.93, 127. WHO.

4 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 62, 1995, pp.217-337, WHO.

5 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 20, 1979, pp.371-389, WHO.

6 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 63, 1995, pp.75-137, WHO.

7 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 63, 1995, pp.159-205, WHO.

8 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 20, 1979, pp.401-417, WHO.

9 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 29, 1982, pp.213-233, WHO.

10 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 29, 1982, pp.215-233, WHO.

11 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 47, 1989, pp.79-107. WHO.

12 IARC Monograph, The Evaluation of Carcinogenic Risks to Humans, Vol., 47, 1989, pp.125-147, WHO.

PM3006517430

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

8. DISCUSSIONS ON RESULTS AND CONTROL STRATEGY ON INDOOR AIR QUALITY

8.1 Introduction

8.1.1 In this chapter the results and conclusions reached in earlier chapters are further evaluated with the ultimate aim to establish grounds for a strategy on the Hong Kong IAQ issue. The subsequent sections will address the key issues of:

(i) The current situation on indoor air quality in Hong Kong buildings - what are the problems and how can they be solved.

(ii) The justification for control measures to be established.

(iii) The options available.

8.2 Current IAQ Situation of Offices

8.2.1 The study concludes that 32% (CI 21%, 44%) of our office premises are classified as sick building based on the definition of acceptability by ASHRAE and WHO. The average BSI (Building Symptoms Index) is 1.774 (for 40 premises) compared the US figure of 1.120 (for 13 buildings). We can thus confidently conclude that occupants of Hong Kong Offices premises are likely to suffer from sick building syndrome at a rate not dissimilar to those in the developed world.

8.2.2 The study showed that there were 37.5% of the premises with mean carbon dioxide levels for an 8-hour period exceeding the ASHRAE guideline of 1000 ppm and 32.5% of the premises with mean 8-hour average of formaldehyde levels exceeding the WHO 30 minute guideline of 100$\mu g/m^3$. There are also high exceedance percentage for air borne and dust borne fungi and bacteria if 500 and 1000 c.f.u./m^3 standards were used respectively. The quantity of fresh air supplied to the offices in the study was also not up to the standard of ASHRAE requirements for over 90% of the cases; the situation would be worst in the winter months as demonstrated by the seasonal variation in the contaminant levels. There were incidents of high levels of organic vapour in offices where redecoration work was being carried out at an adjacent site. All these findings point to the fact that the indoor air quality problem exists, not only because people perceive that they suffer from sick building syndrome, but there are supporting evidence of quantifiable pollutants and parameters which contribute towards the problem.

8.2.3 The extensive correlation studies which were conducted in this study served the purpose of demonstrating that the perception of occupants, measured as satisfaction with IAQ or IAQ perception (IAQP) and Building Symptom index (BSI) did show correlation with the actual measured pollution levels and ventilation conditions in the work place where the observations were made. These perception indicators also correlated well with sickness symptoms as listed in Appendix VIII, which showed a total of 21 symptoms and the observation that the symptom goes away after leaving work. The conclusion was that the classification of sick building (office) based on the perception of the occupants, was also backed up by measured pollutants and ventilation parameters and the actual reporting of sickness symptoms. The imperfection of using IAQP alone as a measure of building sickness was nonetheless recognised. Exposure to formaldehyde and thinner type solvent vapour would need to be measured separately as no positive correlation could be identified. The cause of high formaldehyde level was attributed to new furniture and decorations and the "newness" factor completely overwhelmed the perception of occupants.

PM3006517431

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

8.3 Current IAQ Situation of Public Places

8.3.1 For public places the size of the samples studied was much smaller and was not sufficient to make a meaningful projection to the population. However the observations point to the existence of indoor air quality problems. The results showed that 75% of restaurants and 37.5% of shopping malls have carbon dioxide levels exceeding the ASHRAE standard of 1000 ppm while cinemas had 60% exceedance. This is a significant observation since some of these premises (restaurants & cinemas) are already under legislative control requiring ventilation systems to be designed to a prescribed quantity of fresh air sufficient to provide for the planned occupancy. In the case of the cinema which comes under the Places of Public Entertainment Regulations (Cap. 172) actually requires a performance specification of 1000 ppm CO_2. The conclusion drawn from this study is that although there are provisions in the legislation stipulating conditions for the installation of an adequate ventilation system, the control of the actual situation through the current licensing and inspection system has failed to maintain the design level. This deficiency has to be addressed by instituting more effective control measures.

8.3.2 There were special cases of exposure in restaurants where naked fire using different kinds of fuels (LPG, towngas) was required for the style of cooking offered at the dining table. In these cases, the NO_2 values exceeded the 1-hr guideline of 200μgm^{-3}, and the RSP mean values were above the guideline of 180μgm^{-3}. This type of restaurant justify special licensing conditions such that local exhaust systems may be required.

8.3.3 The control of smoking in restaurants is currently done on a voluntary basis such that restaurants providing non-smoking areas need to display such signs of a prescribed format prominently. There is no requirement for them to segregate the ventilation system. The nicotine levels measured showed an overall mean of 7.4μgm^{-3}, exceeding the OSHA guideline of 6.8μgm^{-3} (8-hour average).

8.3.4 In association with inadequate ventilation, bacteria counts were high in restaurants and shopping malls, with the mean levels well above the 1,000 cfu per m^3 and were in the range of thousand cfu.

8.3.5 The results on the pilot study of IAQ in public places call for action in this area even though the duration of stay at these premises may not be extensive. The exposure may be detrimental to their well being or even subject them to infection. Whilst the current situation does not call for alarm since the public can always choose not to stay in such premises, the quality of the air in the public places of entertainment is not up to the expected standards currently stipulated by law and the deficiency should be addressed by instituting more effective control.

8.4 The justification for control measures to be established

8.4.1 The problems related to IAQ as identified in the study are certainly not critical but they are comparable to developed countries where the IAQ issue is being seriously looked into and control measures are being introduced. Hong Kong as a center for international business where multinationals set up their regional offices and conduct trade and finance, should be providing good IAQ in the work environment. The commitment of government to ensure international standards are followed is a positive attraction to these multinational companies and certainly indoor air quality falls within one of the important criteria.

8.4.2 The competition from neighboring cities such as Singapore is keen. Singapore has already issued an IAQ guideline for offices albeit over simplified. Hong Kong cannot afford to lag behind.

8.4.3 The economic benefit arising from indoor air quality could be substantial and is discussed in general terms in the subsequent section. In order to achieve a more precise assessment,

PM3006517432

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

rigorous economic impact study is recommended such that parameters applicable to local situations can be taken into account.

8.5 Economic Impact related to Indoor Air Quality

8.5.1 The common perception on environmental protection is often negative. Most business people think of measures to improve the environment as a cost to business while the benefits to the general public are difficult to quantify due to the nature of the benefits (i.e., they are widespread and beneficiary may not be identified easily and/or non-specific). In the case of indoor air quality, the situation is quite different as the proprietor is directly involved in providing services beneficial to his/her own work environment and having the issue completely under his/her control. The economic benefits from the improvement on IAQ would definitely offset the cost of the measures required. The government should conduct a more detailed study on the economic evaluation of the impacts of IAQ. The emphasis will be the cost-effectiveness or economic efficiency of resource allocated for improvement in IAQ.

8.5.2 A brief estimate of how the loss due to poor IAQ is compensated by improvement to IAQ is illustrated here as a win-win situation.

8.5.3 *Loss due to Poor Indoor Air Quality*

8.5.3.1 The cost of poor indoor air quality can be mainly accounted for as direct medical costs and loss in productivity. The need for control of IAQ derives from reasons beyond the costs of medical treatment. As evident from our questionnaire survey, the sick leave rate is much lower than the rate of which the occupants express sickness symptoms. The evaluation of loss in productivity is difficult to assess in Hong Kong due to the lack of statistics. As an indication, the US figure of a 3% loss in productivity attributed to poor IAQ is used here for calculation.

8.5.3.2 *Direct Medical Costs*

As evident from this study (though not quantified), as well as from overseas studies, a certain percentage of the working population exposed to indoor air pollution may suffer from adverse health effects and require medical treatment of some sort, whether short term or long term. The USEPA submitted a draft report to Congress on Indoor Air Quality which included a rough estimate of US$1 billion spent annually on direct medical costs attributable to the health effects of indoor air pollution[1]. In a report published by the Commission of European Communities, it lists allergies as occupational diseases where employees are working in buildings with air conditioning systems below standard; the medical costs for such diseases could be enormous but no figures were given.

In Hong Kong, the costs for medical treatment have not been categorised specifically to show the percentage of office workers suffering from indoor air pollution. A survey on prevalence of morbidity in Hong Kong from the statistics on visits to public clinics (Government general out-patient clinics) as well as the private sector clinics may help to shed light on the indoor air quality related sickness rate. It shows that 48.8% of the morbidity is attributed to respiratory system but there is no data on the prevalence of morbidity of the population[2].

From the insurance industry's estimate, the sickness frequency is about 1.5%. From the results of this study's questionnaire survey, the sick leave rate (where medical certificate is usually required) is less than 1% . The overall IAQ related sick leave rate for a three-million working population is thus estimated by assuming the relevant sickness is respiratory (48.8%), of which indoor air quality takes up 30% as the cause. The figure comes to about 1.6 million times annually. If the cost per consultation as out patient is HK$100[3], the total cost for medical expenses is HK$0.16 billion.

PM3006517433

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

8.5.3.3 *Loss in Productivity*

The loss in productivity attributable to indoor air quality is estimated by OSHA in its proposed regulation of Indoor Air Quality to be 14 minutes per day, or 3% of total productivity. For Hong Kong, the current study has shown that although average sick leave rate is less than 1%, the worker actually felt ill on many more occasions, and the rate is close to 3-4%. This figure is further reinforced by the Census and Statistics Special Topics Report[4,5] that while 10% of the economically active population reported they have been ill in the past 14 days, only 3.5% took sick leave between 1/2 day to 4 days in the past 30 days preceding the survey. One can conclude that sickness rate is close to 3-4%.

By taking the 3% bench mark, the loss in productivity is calculated with respect to the income distribution of Hong Kong workers as shown in Appendix XIII-1.

8.5.3.4 The total loss, excluding equipment damage is HK$12.16 billion per year.

8.5.4 *Improvement Costs on IAQ*

8.5.4.1 For the implementation of the control measures to improve IAQ in all indoor conditions, including offices and public places, the capital costs and recurring expenses are estimated. The major costs lie with the ventilation systems. A very rough calculation is shown in Appendix XIII-2. However, the figures are only indicative and a detailed study is warranted before implementing the actual programme.

8.5.4.2 From the calculation on ventilation (details in Appendix XIII-2 & XIII-3), the capital cost amortised over 5 years amounts to HK$0.12 billion per annum while the increase in recurring expenses is HK$0.43 billion.

8.5.4.3 Other costs would be the implementation of the IAQ programme by the private sector which would involve monitoring, training and supervision which are estimated from budget on a health and safety programme of a group of organisations and amounts to HK$0.43 billion per annum.

On the Government side, it owns 10% of total office space in Hong Kong and the current EMSD programme on the monitoring of the ventilation costs below HK$5.0 million per annum. Extending this to a more comprehensive scheme and add the cost of enforcement and monitoring, a budget of HK$0.5 billion per year may be reasonable.

8.5.4.4 The net savings from good IAQ is HK$0.5 billion per year. The economic gain is secondary compared to improving the general health of the population.

8.6 Evaluation of Options Available for Control Schemes

8.6.1 *Country Practice Review*

8.6.1.1 In the evaluation of available options, the first step is to review the experience from other advanced countries on IAQ. This is based on the material collated in the Task 9 Working Report and Chapter 6 of this report which also included the discussion paper on Hong Kong situation.

8.6.1.2 Useful information had been gathered from the eight countries where similarity in trends was observed as well as diversification of approach reflecting social economic and cultural

PM3006517434

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

differences. This information formed a useful basis on which Hong Kong can formulate its own strategy. Options are drawn up based on their experience.

8.6.1.3 The general trend observed is to allow IAQ issues to be controlled under a myriad of legislation which in one way or another, has some bearing on the control of the indoor air quality. This is particularly true for regulations on the design of ventilation / fresh air provisions. Most countries have adopted standards which are similar to ASHRAE catering for health and comfort, e.g. USA, UK, Canada and Australia and regulate through their existing legislations. This practice has been demonstrated to be useful and effective and is certainly a good strategy which can be immediately effective within an existing legislation framework. The only drawback is the lack of enforcement power which can be partially compensated through self-regulatory schemes to be carried out by professionals.

8.6.1.4 The attempt to provide specific bills to govern indoor air quality has been made by USA (IAQ Bill of OSHA drafted in 1993) and the proposed legislation on Indoor Air Management by Korea. The strong resistance to such legislation is evident in both countries due to strong lobby from the tobacco industry and the general apathy towards further controls incurring costs on the public and private sectors. So far they are still continuing with the process of winning approval. There are however, success cases such as in Sweden, where the control of ventilation has taken one step further enacting a special regulation on the Ventilation and Air Quality Ordinance in 1994 to provide specific measures to enhance indoor air quality. In Japan, indoor air quality monitoring is made compulsory by the government for office building management under the Ordinance in office sanitation.

8.6.1.5 By using this multi-department/discipline approach, there may be short falls; namely, a lack of coherence in the various legislation and the existence of grey areas where the existing regulation and enforcement of IAQ control may not cover. This is true for public places and domestic premises where complaints are normally not directed to any government authority in many countries, including Hong Kong where the Occupational Safety and Health Ordinance will only cater for the workplace. There have been cases of more serious indoor air pollution problems arising from the cross contamination of premises in a mixed-activity building resulting in serious injury of the occupants in the affected premises. However such cases fell through the legal loop hole and no control could be exercised. The need to pay special attention to these grey areas is necessary and a mechanism to address complaints from these areas and to exercise some control needs to be worked out.

8.6.1.6 Another difficulty encountered with the multi-department/discipline approach lies with the coordination and division of responsibility between the various government authorities where professional rivalry and in-fighting is common. Both the UK, Canada and USA found it necessary to form a central body to co-ordinate the activities, formulate policies and steer the direction of development on indoor air quality. Different committees under the central coordinating body could be set up to focus on special issues in a more effective manner.

8.6.1.7 The need to provide standards and guidelines related to indoor air quality is recognised by all governments studied. The extent of the requirements may differ from country to country but in all cases, the authorities have recognised two fundamental requirements as follows:

- requirements on ventilation systems
- indoor air quality guidelines (which differ from industrial workplace exposure limits).

8.6.1.8 The WHO has issued various guidelines on indoor air quality in the past decade based on the principles that the standards can cater for the very young and old on a life-time exposure basis. These standards provide a sound basis for individual jurisdictions to develop their own guidelines. Depending on the attainability of the guidelines in different countries, the

PM3006517435

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

proposed standards may be higher or lower than WHO guidelines. Nordic countries as well as NIOSH standards are actually more stringent for many parameters.

8.6.1.9 The existence of standards however does not necessarily mean that they are adhered to. The common problem of poor maintenance of ventilation systems can be found in many countries with sophisticated ventilation standards. Similarly the indoor air quality may not reach the adopted IAQ guidelines. The need for a sound implementation system is obvious. The enforcement of these standards by legislative compulsion may not be available or practicable in many circumstances for a variety of reasons, at least in the short term. In view of that, the best practicable means is to draw up a comprehensive Code of Practice to set the industry standard or the state-of-the-art practice. With this code, people in position of responsibility will have the obligation to follow. In addition, the self-regulatory role of professionals will be an effective way to implement the requirements. Professional bodies can be involved in drawing up the standards as well as implementing them in their practices as in the case of UK on many similar self-regulatory areas.

8.7 Options for Hong Kong

8.7.1 An Overall Evaluation

8.7.1.1 For Hong Kong several plausible approaches to achieve IAQ objectives are explored. The preferred approach is considered in the light of its effectiveness and economic efficiency in achieving IAQ objectives for health promotion and protection.

8.7.1.2 At present, there are already regulatory controls exerting influence on IAQ. The proposed CoP on the management of IAQ will be advocated but its implementation will be on voluntary basis depending on the extent of the economic-based incentive and user awareness. Since the CoP takes less time to develop compared to law making, the target groups can be encouraged to adopt the CoP as soon as it is ready.

For regulatory controls, either through making use of the provisions of the existing regulations or by amendments of the statutes or to introduce a new IAQ legislation would give the authority absolute power. However, there can be potential constraints since the desired changes intended to bring about IAQ controls can only be realised if they are within the scope of the existing regulations. A more in-depth study of the relevant regulations is required to see if it is within the ambit of the law to increase the statutory power of the designated authority (Table 8-1 provides more details).

8.7.1.3 In this evaluation aimed at finding a practicable approach to institutionalise the control of indoor air quality in Hong Kong, the primary considerations are: the ease of implementation, hence the lead time required to put the system in place; the efficiency of the approach in making use of existing control systems and regulations; the enforceability of the approach in the light of constraints, and whether there are overlapping or conflicting situations which hinder the smooth implementation of controls. In some cases, existing regulations or procedure need to be repealed or resolved, hence more cumbersome in the implementation.

PM3006517436

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 8-1 Evaluation of the Different Approaches to Achieve IAQ Objectives from the Administrative Perspective

1	Options	A	B	C	D
2	Approaches	Voluntary	Regulatory		
3	Control methods	Code of Practice Practice notes	Making use of the provisions of the existing regulations	Amend the existing regulations	Introduce a new legislation
4	Descriptions of CoP / regulations	The proposed CoP on the management of IAQ Practice notes e.g., to promote better air quality in car park	Occupational Safety & Health Bill Mechanical and Ventilating Systems Bill	• Building (Ventilating Systems) Regulations, Cap. 123 • Ventilation of Scheduled Premises, Cap. 132 • Places of Public Entertainment Regulations, Cap. 172 • Pesticide Ordinance, Cap. 133 • Customs & Excise Service Ord., Cap. 342 - on import controls, e.g., formaldehyde products	Drafting of a comprehensive legislation to cover all areas (e.g., offices, all commercial premises and public places).
5	Type of statutory duty	None	Absolute duty. Warning notice; withdrew of license etc. within the scope of existing legislations.	Absolute duty. Fine or jail terms within the scope of the legislations.	Absolute duty. Duties & liabilities can be established *ab initio*.
6	Ease in implementing IAQ control with the instruments specified (i.e., to "kick-off")	• Takes less time to develop compared to law-making • Less intrusive • More responsive to technological change • Cheaper to enforce for all concerned	Drafting (Technical memorandum etc.) by departments or designated authorities to achieve IAQ-objectives if it is falling within the ambit of the law.	Drafting of provisions (as amendments) by legislative process and it is time consuming. It must also be within the scope of the existing legislations.	Law enactment is a time consuming process. However, a definitive legislation has the advantage since it is designed to translate policy objectives of IAQ into concrete terms for achieving desired objectives.
7	Assurance of goal achievement	Depends on market forces; user awareness; not subject to control by authority.	Enabling legislation required.	Enabling legislation required.	Enabling legislation required. In this case, achievement of IAQ-O is assured if there is little change to the spirit of the law (i.e., the intention of the law is not compromised during the legislative process)
8	Potential objection from interested/ affected parties	Unlikely	Subject to lobby; opposition by affected trades/ parties.	Subject to lobby; opposition by affected trades/ parties.	Legislative control contradicts the principle of the free market; thus, subject to political forces by parties affected (esp. business sectors where health & safety is not an issue).

8.7.1.4 The self-regulatory approach of adopting the Code of Practice on IAQ management through the issuance of Pro-PECC notes would certainly be the most expedient method to implement

PM3006517437

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

the standards and control on IAQ, but the authority to deal with non compliance would be minimal. However, it would be worthwhile to give this option a try since the time and effort required to introduce the Code of Practice would be little. The effectiveness of this approach can be monitored in the next two years and a review can be carried out in the third year to formulate future policy dependent on the two years' actual experience.

8.7.1.5 In parallel to the issuance of Pro-PECC notes (option A), the inclusion of the requirements on IAQ can be explored if it is falling within the ambit of the law (option B). This may have some resource implication for the government and the private sector and hence would need some negotiation and balancing.

8.7.1.6 Although regulatory amendment (option C) is by legislative process and it requires more time, it is always useful from the strategic point of view not to rule out such a possibility if it is within the scope of existing legislations (i.e., to introduce matters related to health and safety). The general response of management is to adopt precautionary measures well in advance in anticipation of the enactment of the proposed legislation. This would certainly help in achieving the objective of improving IAQ.

8.7.1.7 The legislative process (option D) is tedious and lengthy and the idea itself may attract much opposition from the conservative business sector. However, the prospect of having an IAQ regulation should be kept in view as it is most effective in terms of enforcement.

8.7.2 Evaluation by Individual Approach

8.7.3 **Option A:** *Voluntary Approach - Code of Practice and Practice notes*

8.7.3.1 This option has the advantage of fast-track implementation by the issuance of Pro-PECC notes to professionals involved in building design, operation and maintenance. A draft Code of Practice has already been submitted as described in Chapter 7 and the proposed IAQ-objective is included in the Code.

8.7.3.2 The Code allows flexibility in the implementation process depending on resources available. On the other hand it also gives clear guidelines to building designers and owners what is the state-of-the-art practice. New buildings no doubt will follow the Code while maintenance programme for HVAC in existing buildings may be required to meet higher standards than those at the time they were built.

8.7.3.3 The only disadvantage of this approach is that the government has no authority to monitor the situation on IAQ in private premises. It can of course take the lead and apply such standards to its own buildings as the USEPA. For prudent private property owners and building managers, bad publicity due to poor IAQ in their buildings could be disastrous to the building's market value, more so than litigations in this area.

8.7.4 **Option B:** *Imposing Standards (IAQ Objectives) on Existing Regulations and Licensing System.*

8.7.4.1 These include the Occupational Safety and Health Ordinance and the proposed Mechanical and Ventilating System Bill.

8.7.4.2 The Occupational Safety and Health Ordinance enacted in May, 1997, has a regulation which requires all workplace to be free from air impurities, which in essence, governs the indoor air quality in offices and commercial settings with an employer-employee and occupier-persons

PM3006517438

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

employed relationship. Although the Labour Department has yet to come up with a set of standards and has so far continued to refer to its "Reference notes an Occupational Exposure Limits", it is expected that they will issue suitable air quality guidelines (e.g. Carbon dioxide) which is more appropriate to apply in office environment. This is in line with the world trend.

Similarly, the Mechanical and Ventilating System Bill will be directly related to indoor air quality. The requirements for adequate ventilation as specified in ASHRAE is recommended as there already exists such provision within these proposed legislations notwithstanding that the original ASHRAE standard is now uncertain and neither has the revised standard been adopted. It is because ASHRAE standard is well adopted worldwide.

8.7.5 **Option C**: *To draft New Provisions(Amendments) Specifically on IAQ Control under Existing Ordinance*

8.7.5.1 The situation in this option may be very similar to that in option B, but instead of a simple administrative procedure of changing licensing conditions and performance standard, an additional regulation specifically requiring the compliance to indoor air quality standards is introduced.

8.7.5.2 The Urban Services Department (USD) issues operating licenses for restaurants, cinemas, theatres, dancing establishments etc. (Schedules Premises, see Second Schedule, Cap. 132) (Public Health and Municipal Services Ordinance, Cap. 132 and Places of Public Entertainment Regulations, Cap. 172). One of the possible measures to achieve the specified standards is to require monitoring by the proprietor before re-issuance of license, or to impose a requirement of regular monitoring implemented by the proprietor themselves for records which the USD inspector can have access to. It needs to be clarified whether such requirements involve an amendment to the legislation. More importantly, it must be within the scope of the legislation before the amendments can be made. The IAQ conditions may be considered part of the requirements to fulfill the ventilation goals: health and safety. This comes down to the flexibility of licensing conditions and if this aspect of control falls within the ambit of the law. Amendment may be considered to extend the schedule premises to cover shopping malls too.

8.7.5.3 The Building Ordinance (Cap. 123) has provisions for ventilation requirements although at the moment this is implemented as the industry's best practice. It would be possible for IAQ requirements to be included in this section so that all new buildings can take into account such requirements at the design stage.

8.7.5.4 For the Building Ordinance, the current coverage does not include the operation and maintenance of the mechanical ventilation system. Hence apart from introducing the indoor air quality standard and the associated ventilation requirements for design stage, an additional section on operation and maintenance is required. In fact the proposed Mechanical Ventilation System Bill covers such requirements.

8.7.5.5 An indoor air quality regulation can be introduced into the Air Pollution Control Ordinance to cover all public areas and commercial premises not covered by the above ordinances and provides the power to set standards on material emissions and IAQ standards.

8.7.5.6 The control of pesticide application by professional pest control companies cannot be covered by the Consumer Product Safety Ordinance. It may be possible to introduce a regulation under the Agricultural and Fisheries Ordinance to control the use of pesticides in quantities exceeding certain limits.

PM3006517439

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

8.7.5.7 The control of emissions such as formaldehyde from building and furnishing materials could be controlled under the Consumer Product Safety Ordinance with EPD specifying the emission standards for commonly used items such as chip boards, ready-made plywood furniture etc. The ordinance arguably does not cover office equipment but a lot of the building materials are used domestically. This will involve an enabling legislation under EPD.

This approach may be powerful in enforcement but requires lead time as well as efforts in coordination in the future.

8.7.6 **Option D**: *New Legislation*

8.7.6.1 It is always possible that a separate ordinance on IAQ be drafted to cover all commercial premises and public places. The regulation will define standards for IAQ as well as emission standards, ventilation design and maintenance requirements, monitoring requirements and record keeping. The penalties for non-compliance also need to be defined. The coverage of premises can be announced from time to time by the schedule of premises so that the implementation can be by phases. The legislation will have to supersede all existing measures currently available in the other ordinances and will need to set up a team to deal with updating standards, vetting building/license applications and enforcement of the standards through inspection. The obvious drawback for such a system is the lead time require to come up with the legislation, the overlap with existing laws (hence the process of repealing existing ordinance) and the associated problem of manpower and resources re-structuring and increase.

8.8 The Way Forward

8.8.1 Setting Up of an IAQ Management Group

8.8.1.1 As discussed in the country practice review, a dedicated body to coordinate the development on the control of IAQ is essential, hence an IAQ Management Group (IAQMG) is recommended (details on the proposed structure of the Coordinating Management Group is in Appendix XIII-4).

8.8.1.2 The options available for IAQ control are listed out and the IAQMG will play the coordination role to ensure a coherent programme is being developed. A summary of what each relevant department already has or will have in the control of IAQ is presented in Table 8-2. As most of the implementation will take time (even if a policy agreement is reached) the IAQMG will keep the momentum going and play the role of coordinating the IAQ activities of different departments, reviewing progress, standards and setting targets to measure achievement. The indicators for the IAQ programme may include a central collection of complaint cases, a re-survey of people's perception and a re-measurement of some of the key indicators of IAQ at the survey sites.

8.8.1.3 The proposed IAQMG will work towards the following:

- to oversee the implementation of IAQ Code of Practice
- to coordinate all activities related to IAQ standards
- to initiate review on the IAQ standard on regular basis and advise on changes to the appropriate authority
- to monitor, educate and promote as well as to oversee continued collection of data on IAQ

PM3006517440

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

- to assess the technology (including any new innovations) available for IAQ control
- to incorporate existing "grey areas" into its management so as to ascertain a minimum standard of IAQ in these premises (esp. public places)
- to devise measure to control and reduce exposure of occupants to residue pesticides
- to keep abreast of all new development (including those overseas, regional and international) in IAQ, e.g., legislation on IAQ
- to work towards enhancing existing IAQ of buildings through innovative means, e.g., to provide incentive for building management to re-examine its fresh air intake
- to advise on the phased introduction of schedule of premises to be controlled in related regulation

8.8.2 IAQ Programme Assessment

8.8.2.1 Useful indicators to monitor the progress on the improvement of indoor air quality would include a continuous monitoring programme targetting at the parameters which do not comply with current IAQ objectives. The expectation would be to have complete compliance by three years, but set a goal for 50% compliance by the second year.

8.8.2.2 Other appropriate indicators would be to collect records of complaints on IAQ in offices and public places. These may come through the various departments such as Labour Department as a result of their campaign on health and safety at work, or through the Urban Council's/USD's section on hygiene and health inspection, or general complaints on IAQ to EPD. A proper system to collect and collate complaints information should be set up by the IAQ Management Group to extract useful indication on the success of the IAQ implementation programme.

8.8.2.3 Other more specific industries such as pest control contracts, furniture suppliers and ventilation/air-conditioning contractors etc. should also be identified such that their voluntary actions to improve according to IAQ requirements can be somehow measured through their trade associations cooperation. The assessment methodology can be in the form of questionnaire surveys.

8.8.2.4 A consensus was reached by the Steering Group on the IAQ Study that the Environmental Protection Department will be the convener of the IAQMG of the future and continue to take the lead in developing an overall system to institutionalise the control of IAQ. The Steering Group also recommended that ad hoc groups be set up to focus on specific issues which may require the input of specialist expertise (e.g., microbiology). With a plethora of such working groups, issues may be dealt with concurrently to speed up the process. The IAQMG will then consider the recommendation from these working groups and follow up on the implementation.

PM3006517441

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table 8-2 Summary of Responsibilities of Government Departments Relevant to IAQ

Department	Legislation	Relevance to IAQ	Current Status
Electrical & Mechanical Services Department	Proposed Mechanical Ventilating Systems Bill	Requirement on ventilation design and maintenance operation regime, enforced via building consent and license to operate	Expected to be enacted in 2-3 years.
Buildings Department	Building Ordinance Cap. 123	Requirement for mechanically ventilated premises to provide 5 air changes per hour.	Not enforced. Does not require detailed submission at the moment. Can be readily modified.
Urban/Rural Council (UC/RC)	Public Health & Municipal Services Ordinance, Cap. 132	Ventilation ducts are inspected yearly by registered ventilation contractor. Specified ventilation rates for scheduled premises.	Enforceable in practice
	Places of Public Entertainment Regulations, Cap.172	Requires provision of a supply of outdoor air at the minimum rate of 30 m^3 per occupant per hour. Requires a CO_2 level of not more than 10 parts in 10,000.	Enforceable in practice
Labour Department	Factories & Industrial Undertakings Ordinance, Cap.59	Requirements to protect workers (workplace safety and measures of work practice as well as medical surveillance).	F&IU Ordinance - enforceable in practice
	Occupational Safety & Health (OS&H) Ordinance	Requires the provision of safe and healthy workplace for office workers in addition to industrial workers. Provision of adequate ventilation & air within workplace should be kept free of impurities.	O&SH Ordinance has been enacted with effect from 23 May, 1997
Health Department, Commission of Police, UC/RC, TV & Licensing Authority	Smoking (Public Health) (Amendment) Ordinance, Cap. 371; Code of Practice under Broadcasting Authority Ordinance	Control measures relating to prohibition of advertisements, designated 'No Smoking" areas, 'No Smoking' signs, etc.	Enforceable in practice
Customs & Excise Department	Consumer Goods Safety Ordinance, Cap. 456 Ozone Layer Protection Ordinance, Cap. 403 Air Pollution Control Ordinance (APCO), Cap. 311	Control of import of consumer goods with focus on product safety and enforcement of import control on ozone- depleting substances & asbestos through import licensing (as authorised by EPD).	Enforceable in practice
Agriculture & Fisheries Department	Pesticide Ordinance, Cap. 133	Control of import, manufacture, supply & sale (but no control of use of registered pesticides).	Enforceable in practice
Environmental Protection Department	Air Pollution Control (Amendment) Ordinance, Cap. 311	Established Air Control Zones and the associated Air Quality Objectives Control of asbestos in environment.	Enforceable in practice

PM3006517442
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

1 Federal Register Lot 59 no.65 April 94 (Proposed Rules) (29CFR Parts 1910, 1915, 1926 & 1928 IAQ, Proposed Rules)

2 Albert Lee et al "A morbidity survey in Hong Kong, 1994, Research committee, the Hong Kong College of General Practitioners.

3 Barron, W.F., Liu, J., Lam, T.H., Wong, C.M., Peters, J. and Hedley, A. 1995. Costs and Benefits of air Quality Improvement. Contemporary Economic Policy. Long Beach, US. Vol. XIII, Oct., 1995.

4 Census and Statistics Department, Hong Kong. 1994. Special Topics Report No.X. Social Data Collected by the General Household Survey. Social Analysis & Research Section of the Census and Statistics Department. Government Printer, Hong Kong.

5 Census and Statistics Department, Hong Kong. 1994. Special Topics Report No.11. Social Data Collected by the General Household Survey. Social Analysis & Research Section of the Census and Statistics Department. Government Printer, Hong Kong.

PM3006517443

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

9. OVERALL CONCLUSION AND RECOMMENDATION

9.1 The study has concluded that 32% of the office buildings in Hong Kong may be identified as 'sick' buildings where the indoor air quality is sub-standard and attributed as the cause of sick building syndrome experienced by its occupants. From the measurement of levels of air pollutants in forty office premises and the detailed evaluation of their air conditioning and ventilation systems, the exceedance observed in levels of carbon dioxide (37.5%), formaldehyde (32.5%), fungal count (12.5%) and bacteria count (12.5%), together with the observation that 90% had substandard air-conditioning and ventilation system in term of fresh air supply and temperature range, the sources and causes of sick building were quantified.

9.2 Analytical statistics further illustrated the significant statistical correlation between occupant's perception on indoor air quality and most of the above measured quantities as well as other contributing physical factors including new carpets, use of various office equipment, stationery and external agents such as chimneys in the vicinity. However there are important pollutants such as formaldehyde levels and vapours from commonly used thinners (toluene, xylene and benzene) which were not perceived by occupants as poor indoor air quality. Their perception could be overshadowed by the "feel good" factor of newly decorated conditions which were associated with increased levels of these pollutants. While more practical steps to develop expertise in testing and analysis of the full range of pollutants and microbial contaminants should be taken, the need to be aware of these causes was highlighted.

9.3 The consultant recommends that building proprietors, managers and designers should take positive steps to mitigate the problems by appropriate management and technical measures.

9.4 The acceptable guidelines and methodologies are available in the Code of Practice produced by this study. Special attention should be paid to pest control practices to ensure safe products and application methods are used. Furniture and materials emitting gaseous pollutants can be controlled at source. There was no significant correlation between levels of pollutant in indoor air with outdoor air except for RSP, with indoor air at a lower level as dust was trapped by filters in the ventilation system. Pollutants which showed higher levels indoor from outdoor had indoor emission sources, such as carbon dioxide, carbon monoxide, formaldehyde, VOC's, radon as well as bacteria and fungal counts. This demonstrates the importance of controlling the indoor air quality which can effectively reduce exposure of occupants in an indoor environment.

9.5 The overall levels of indoor pollutants were significantly higher in the winter season than those in the summer and this observation could be attributed to the lower fresh air percentage supplied to the ventilation system in the winter since all systems studied had no heating in the winter. Building management should look into this problem as they improve the ventilation system.

9.6 Carbon dioxide levels in public places were exceeded in restaurants (80%), cinema (60%) and shopping mall (37.5%); the former two categories of premises in fact have not complied with the Places of Public Entertainment Regulations' requirement of 1000 ppm CO_2 level. Other pollutants such as nitrogen dioxide were found to exceed the level of 150 $\mu g/m^3$ in restaurants of special cuisine using naked flames in the dining areas. RSP levels and nicotine levels were also in exceedance of 60%, and 21% in restaurants despite the fact that no-smoking areas were declared in parts of the restaurant.

9.7 The consultant recommends that the legislative requirements on public places with regard to carbon dioxide level should be strictly enforced in cinemas and restaurants with the licensing

PM3006517444

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

conditions stipulating compliance. The schedule of premises controlled by the Places of Public Entertainment Regulations should be extended to large shopping malls over a reasonable size (say 5,000 m^2) such that the indoor air quality could be controlled.

9.8 For restaurants in general, the current smoking control measure is insufficient and efforts should be made to require segregation of ventilation systems to effectively control the entrainment of tobacco smoke to no-smoking areas. Adhering to a set of Code of Practice designed for this purpose or administrative requirements on smoking policy would yield positive improvement to the air quality indoor in such premises. For restaurants with naked fire in the dining area, the local exhaust provisions should be required to achieve IAQ-Objectives of NO_2 and CO.

9.9 The MTRC monitoring results showed acceptable IAQ at the concourses and platforms under very crowded conditions. Carbon dioxide inside train compartments during peak-hour period was the only indoor air contaminant that exceeded the comfort-based level. However, the levels recorded are comparable with the USA subway guidelines. Public's exposure is limited as the maximum travel time on the MTR is only 1-2 hours per day. The crowded situation of MTR during peak hours is likely to persist and it is understood that the MTRC management is working hard in improving the situation, with the priority of dealing with under emergency situations where full loads of trains may be trapped for extensive periods.

9.10 Radon was studied in 1,784 premises by the EPD and a regression model was constructed. The conclusion drawn from the EPD Radon study conducted in 1992/93 and 1995/96, stated that both in residential and non-residential premises, the levels of radon were generally within the safety guideline of 200 Bq/m^3. The publicity and awareness programme conducted since 1995 has been demonstrated to be effective as a general reduction in radon levels was observed and the provision of good ventilation was indeed an efficient mitigation measure.

9.11 The consultants provided a series of tools to assist building designers, building managers, proprietors and occupants to improve indoor air quality through a list of technical mitigation measures, computer simulation software to estimate the impact in relation to design factors and regression models to predict the pollution levels. Building designers and managers are recommended to use these tools in planning and management in order to achieve acceptable IAQ in their buildings. For the government, a SQL database was constructed to facilitate continued efforts in data collection and collation on IAQ in the territory.

9.12 On a broader perspective, the consultants recommends that an overall control scheme should be set up to manage IAQ in buildings in a coherent manner. The legislative system, regulatory measures and state-of-the-art practice in eight developed countries were studied and many of the useful experience had been amalgamated into the "Code of Practice on Indoor Air Quality Management" produced for Hong Kong in this study; in particular, the setting of a three-level indoor air quality objective (IAQ-O) for Hong Kong offices and a short-term level for public places. These IAQ-Os have been drawn up using international guidelines as a basis and modified to accommodate the attainability of Hong Kong premises. The importance of IAQ-O cannot be over-emphasised as it provides a target for industry and individuals to work towards.

9.13 Apart from the Code of Practice, a full discussion on the available options to institutionalise the control of IAQ in Hong Kong was presented with the merits and demerits of the options laid out. A central management group co-ordinated by EPD was recommended to steer, monitor and implement the system which may draw on any of the four options as appropriate. The consultants also recommended a review in three years on the IAQ issue in Hong Kong, with the Management Group closely monitoring progress using indicators specially for the

PM3006517445

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

purpose. The interaction between the CoP and HKBEAM needs to be encouraged to work towards improving the ventilation of new buildings through architectural design.

9.14 The consultant also recommends that an education and promotion campaign should be conducted by the Government to bring up the public awareness on IAQ. For domestic premises (not studied in this report), where the jurisdiction lies with the occupants themselves, the understanding of their own indoor air environment is particularly important so that they can take up the proper management of IAQ on a voluntary basis. It would be useful to establish a contact/ information centre to which questions and requirements for measurements could be addressed.

9.15 Other premises which have not been studied in this consultancy are of equal importance from IAQ point of view; they are: hotels (and service apartments), schools and hospitals. IAQ issues in enclosed premises such as air plane travel has been brought to public attention by the *Guardians*. The new Occupational Safety and Health Ordinance requires the occupier of premises to ensure safety and health of persons employed at those premises where an employer-employee or occupier-persons employed relationship exists. The provision of more specific regulations under this Ordinance would be essential to make the enforcement effective on the part of the authority, while at the public end, they also need the specificity for implementation purposes. The grey area which falls outside the 'employer-employee' definition, such as cross contamination, still needs to be addressed. A case which has direct implications is that of pesticide poisoning in Hong Kong leading to an award of HK$24 million for damages (South China Morning Post, 1 August, 1997).

9.16 As with all environmental, health and safety issues, the question of economic benefit of improving IAQ comes into scrutiny. There are obviously costs in upgrading "hardware" set up (such as ventilation) and "software" management system in enforcement, monitoring, licensing and complaints investigation related to IAQ. However, the consultants in its preliminary economic analysis has illustrated that such cost will be more than offset by the gain made in the reduction of medical cost and regaining the loss in productivity due to "sickness" at work. The consultant recommends a more detailed economic impact study to address this important issue.

9.17 Apart from the win-win situation of optimal health and higher productivity, Hong Kong also needs to see the issue of indoor air quality eye-to-eye with the developed countries as well as other Asian cities. To continue as a regional hub and an international centre for trade and finance, Hong Kong has to demonstrate some guarantee on the quality of life in order to attract multi-nationals to be stationed in the territory. The guarantee of good indoor air quality of buildings is one of the very important criteria since people spend most of their life indoors. Government regulations and setting of standards play an important role in ensuring the provision of such environment to its people, so that it would not result in unnecessary challenges. The consultant therefore believes that it is time to act to improve the indoor air quality in our buildings and to provide an effective, compatible scheme within the present administration legal system to institutionalise the control. Government buildings should take the lead for voluntary control.

9.18 Future evaluation to determine the IAQ situation in Hong Kong may involve similar data collection. With the deliverables from this project, the authority shall be in a better position to perform the task since data collection of the relevant indicators will be an on-going process. In addition, some other relevant data can be supplied by the IAQ Management Group members, such as the Department of Health (on IAQ related respiratory problems).

PM3006517446

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX I

Programme of Seminar on Indoor Air Quality

PM3006517447

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

PROGRAMME

Indoor Air Quality Seminar
January 19, 1996
Regal Hong Kong Hotel, B1 Monaco Room

9:00 - 9:15	Registration
9:15 - 9:30	Dr. Margaret Chan (Department of Health) Opening Remarks
9:30 - 10:00	Mr. C.W. Tse (Environmental Protection Department) Government's Role in Controlling Indoor Air Quality
10:00 - 10:30	Prof. John Spengler (Harvard School of Public Health) Overview of IAQ and Health Concerns
10:30 - 11:00	Coffee Break
11:00 - 11:30	Dr. Tao Ho (TAOHO Design & Architects) An Architect's Perspective on Indoor Air Pollution
11:30 - 12:00	Dr. James Day (King's General Hospital, Ontario) Health Aspects on Indoor Air Pollution
12:00 - 12:30	Panel Discussion - chaired by Dr. Sarah Liao
12:30 - 2:00	Lunch
2:00 - 2:30	Prof. John Spengler (Harvard School of Public Health) Indoor Air Pollution - Office Buildings Sick Building Syndrome and the Possible Contributors
2:30 - 3:15	Mr. Andrew Wong (Associated Consulting Engineers) Designing/ Investing for Indoor Air Quality
3:15 - 3:45	Coffee Break
3:45 - 4:15	Dr. Lilian Vrijmoed (City University, Hong Kong) Microbes in Indoor Environment
4:15 - 5:00	Panel Discussion - chaired by Dr. Sarah Liao

PM3006517448

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX II

ASHRAE Standard (62-1989R) as the Proposed New Minimum Air Supply Rate (MSR)

PM3006517449

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

II. ASHRAE STANDARD (62-1989R) AS THE PROPOSED NEW MINIMUM AIR SUPPLY RATE (MSR)

II.1 The new set of ASHRAE Standard 62-1989R (ASHRAE, 1996) proposed that the minimum supply rate (MSR) for each space served by the ventilation system be either 100% outdoor air or a mixture of outdoor air and recirculated air. It is necessary to ensure that the MSR to any space shall be the larger of 7.5 L/s per person, based on the design occupancy, and the design ventilation rate, adjusted for the air change effectiveness of that space.

II.2 According to the method of calculation used by ASHRAE (1996), every premise will be calculated separately by using the prescribed outdoor air requirements which prescribe minimum ventilation requirements. These requirements are intended to achieve acceptable indoor air quality by dilution ventilation for various indoor spaces, when all other applicable requirements of this standard are met and the spaces are thermally comfortable. Requirements of Table II-1 is also based on "no smoking".

II.3 By using the formula as shown below, the MSR calculated, whichever the bigger, will be the accepted value. Thus, 7.5 will only be used whenever the MSR calculated is less than 7.5.

$$MSR \geq \frac{DVR}{E_{ae}} \text{ and } \geq \frac{7.5P_D D}{E_{ae}}$$

Where,

DVR is the design ventilation rate for each space. The DVR required in the occupied zone of each space shall be determined as follows:

$$DVR = V_P + V_B = R_P P_D D + R_B A_B$$

Where,

V_P	=	outdoor ventilation rate (L/s) required to dilute odorous bioeffluents from occupants and other sensory contaminants that result directly from occupant activities.
V_B	=	outdoor air ventilation rate (L/s) required to dilute sensory contaminants emitting from materials and furnishings within the space, from non-occupant activities and processes taking place within the space, and from the building ventilation system itself.
R_P	=	the outdoor air requirement per person from Table II-1 to dilute emissions from occupants and occupant activities.
P_D	=	the design occupancy (persons)
D	=	the occupant diversity factor (dimensionless)
R_B	=	the outdoor air requirement per unit area from Table II-1 to dilute contaminants emitted from non-occupant ("building") sources.
A_B	=	the net occupiable floor area of the space, m^2

Table II-1: Outdoor Air Requirements

PM3006517450

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Application	Prescriptive Requirements	
	People R_P (L/s. person)	Building R_B (L/s. m^2)
Offices	2.5 - 3.5	0.3 - 0.35
Hotels	2.5 - 3.5	0.35 - 0.75
Shopping Areas		
Sales floor	3.5	0.85
Supermarket	3.5	0.30
Sports and Amusement		
Gymnasium, stadium	10	0.20
Disco/dance floors	7.5	0.35
Theatres		
Auditorium seating area	2.5	0.35
Stages, studios	5.0	0.35
Lobby	3.5	0.35
Education		
Lecture classrooms	3.0	0.55
Food & Beverage Service		
Restaurant dining rooms	3.0	0.85
Cafeteria, fast food, dining hall	3.0	0.60
Bars, cocktail lounges	3.0	0.85
Commercial kitchens	4.0	2.85

Source: ASHRAE, 1996[1]

[1] ASHRAE (1996) BSR/ASHRAE Standard 62-1989R, Ventilation for Acceptable Indoor Air Quality Public Review Draft. Atlanta.

PM3006517451

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX III

Details on Factors Affecting Indoor Air Quality:

Physical Factors and Emission Sources

PM3006517452

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

III. DETAILS ON FACTORS AFFECTING INDOOR AIR QUALITY: PHYSICAL FACTORS AND EMISSION SOURCES

III.1 Since the realisation that sick building syndrome (SBS) is associated with exposure to low level of emissions indoor, there is an increasing concern in the minimisation of human exposure to indoor air pollution. However, provided we have an understanding of the factors affecting IAQ, no effective solution on source control may come about.

III.2 There are many factors which can contribute to IAQ problems. It is therefore necessary to adopt a systematic approach to narrow the range of possibilities. Thus, the factors affecting IAQ can be grouped as follows:

III.2.1 *The physical conditions of the building*

The physical conditions of the building include, for example: building design, age, location, floor level and occupation density, affect the pollution load. In the case of modern buildings, air tightness which is associated with energy conservation meant that little natural ventilation is available. On top of this is the increasing use of synthetic materials which may emit pollutants. Location is a significant factor because of air infiltration especially in areas with poor ambient air quality, such as established industrialised area or prime commercial area with heavy traffic.

III.2.2 *Mechanical, ventilation and air conditioning (MVAC) system*

This system is intended to provide thermal comfort, in particular temperature and humidity control and air distribution. Sometimes, the system installed may not be well functioning or its design may fall short of the requirement to meet the occupancy density and floor layout. Occupants are known to generate pollutants such as carbon dioxide and water vapour. In designing for an effective ventilation system, apart from taking into account the number of occupants, the density and the distribution of the occupants, the furniture layout is also important. Blockage of proper air circulation by furniture and fixtures will cause a drastic drop in the effectiveness of ventilation. In an area where occupants are sparsely distributed, there may be excessive cooling but at the same time there may be insufficient freshair input and air changes causing carbon dioxide, heat and odour to accumulate.

III.2.3 *External factors*

The external factors include, for example: outdoor air quality and cross contamination. Outdoor pollution may come from industrial emissions and vehicular emissions. Outdoor air is drawn in as "fresh air" to dilute contaminants generated indoors. However, if the air drawn into the indoor premises is already burdened with pollutants, it will affect IAQ. These types of pollutants from outside sources are: particulate, SO_2, NOx, CO and VOCs. Radon enters the buildings from air that is drawn from the underlying soil by the "stack effect" phenomenon. The stack effect is due to the tendency of air to rise whenever it is warmer than surrounding ambient air. When indoor air is warmer than outdoor air, air flows through the lower portions and out from the upper portions of the building outer envelope, creating a differential between indoor and outdoor air pressure. Infiltration occurs through gaps and openings present in the building envelope. Entry rate of radon depends upon soil permeability, meteorology, structural, and other geological factors. Pesticides and fertilisers sprayed into the soil outside buildings

PM3006517453

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

can also enter the building in the same way. Other typical sources of radon in indoor air are utility natural gas and water, and certain types of building materials.

III.2.4 *Factors other than air pollutants*

These factors include, for example: temperature, humidity, lighting and noise. In view of the potential impact of the outdoor air, all chemical measurements were also performed outdoor during on-site survey. In addition, weather conditions on the day of the survey were recorded.

III.2.5 *Materials and equipment affecting IAQ*

Office equipment such as computer terminals, photocopying machines, laser printers, electric typewriters, and fax machines are standard equipment in most office buildings, they may contribute to IAQ problems in workplace. Research in this area has found that these equipment tend to emit a number of contaminants, in particular VOCs, ozone and particulate. The extent of these emissions depends on the type of equipment and processes involved, as well as the intensity of use of such equipment.

III.3 The health effects of exposure to a selected list of air contaminants are shown as follows:

III.3.1 *Carbon Monoxide*

III.3.1.1 Carbon monoxide (CO) is a colourless and odourless gas which may result from incomplete combustion of any carbon containing fuel. Natural background levels of CO range between 0.01 and 0.23 mg/m^3 (0.01 to 0.20 ppm). In the urban environment where traffic is heavy, the CO level is expected to be higher.

III.3.1.2 The use of gas appliances can also result in an increase in the CO level. Another possible cause of a raise CO level is smoking. It tends to raise the mean CO concentration of indoor air significantly.

III.3.1.3 CO has a strong affinity with haemoglobin. It is about 200 times as effective as oxygen in combining with haemoglobin to form carboxyhaemoglobin (COHb). As such, it will affect the ability of the red blood cells in carrying oxygen to the body tissues. Carbon monoxide can have detrimental effects on the heart, lungs and nervous system. For example, the study by WHO indicated that at COHb levels 5 - 10%, neurobehavioural effects such as impaired co-ordination and cognitive performance may be noted. Intoxication from CO may be acute or chronic, depending upon concentration and duration of exposure.

III.3.2 *Carbon Dioxide*

III.3.2.1 Carbon dioxide (CO_2) is a colourless gas, produced by combustion, unvented appliances and the normal metabolic activity of building occupants. Ambient concentrations of CO_2 tend to be fairly constant at 350-450 ppm.

III.3.2.2 The concentration of CO_2 in exhaled human breath is typically around 3.8% (38,000 ppm). Indoor concentrations of CO_2 in occupied spaces typically range from 500 to 2,000 ppm. The difference between inside and outside concentrations in most non-industrial workplaces is primarily due to the CO_2 produced by building occupants.

III.3.3 *Sulphur Dioxide*

PM3006517454

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

III.3.3.1 Sulphur dioxide (SO_2) is primarily results from the combustion of fuels containing sulphur. Local emission from industrial sources or traffic in the street may elevate the level of SO_2 which may enter buildings by air infiltration. The concentration indoor is normally lower than outdoors (roughly half) because of adsorption or reaction.

III.3.3.2 The inhalation of SO_2 causes irritation of the respiratory tract, mucus secretion or increased airway resistance. Conditions such as respiratory weakness and sensitised asthmatics may be aggravated by exposure to SO. Since SO_2 is not generated by indoor sources, it would not serve as a good indicator for IAQ.

III.3.4 *Nitrogen Dioxide*

III.3.4.1 Nitrogen dioxide (NO_2) comes from the oxidation of nitrogen in air under high temperature. in In Hong Kong, the emission of nitrogen oxides is attributable to electricity generation. Indoor sources of NO_2 may come from entrained exhaust.

III.3.4.2 NO_2 has significant health effects. It is a deep lung irritant which has been shown to result in biochemical alterations. Animal tests have demonstrated lung damage in laboratory animals as a result of both acute and chronic exposures.

III.3.4.3 For chronic exposures, substantial changes in pulmonary function can be demonstrated in normal, healthy adults at or above concentrations of 2 ppm[1]. Asthmatics are likely to be the most sensitive subjects. The lowest reported effect on pulmonary function for mild asthmatics was an exposure of 30 minutes at concentration of 560 $\mu g/m^3$ (0.3 ppm) during intermittent exercise.

III.3.5 *Respirable Suspended Particulate (PM_{10})*

III.3.5.1 RSP are suspended particles in air with a nominal aerodynamic diameter of 10 micrometres (μm). They are released from indoor combustion sources and may include polynuclear aromatic hydrocarbons (PAH) compounds, trace metals, nitrates, and sulphates. PAH compounds are of particular concern because of their carcinogenic potential. Once they are airborne, they can adsorb onto respirable sized particles and inhaled into the lungs.

III.3.5.2 The health effects of particulate will depend not only on the size, shape, density and reactivity of particulates, but also the velocity of the airway. These factors will determine how the particles will be deposited in the human respiratory tract. Particles greater than 10 μm in diameter and about 60-80% of particles of 5-10 μm are trapped in the nasopharyngeal region. At the same time, another 5% of particles smaller than 5 μm in diameter are also trapped in this region, leaving the remaining (95%) of the RSP which travel deeper into the lungs. These particles may cause severe damage at the cellular level.

III.3.6 *Environmental Tobacco Smoke (ETS)*

III.3.6.1 It is the single largest contributor to indoor air particulate concentrations in office buildings where cigarette smoking occurs. A number of studies have demonstrated that the gaseous phase of ETS accounts for most of the odour and irritation. The particulate phase adsorb to surfaces and emit more irritating and odorous gaseous components an hour or so after emission of smoke[2]. Some studies have documented that workplace exposure to nicotine to 2.3 $\mu g/m^3$ for 40 years presents a risk of obvious concern. The US Occupational Safety and Health

---

1 Manahan , Stanley E. Gaseous Inorganic Air Pollutants. *Environmental Chemistry*. 5th Ed. pp. 269-293.

2 Clausen, G.H., P.O. Fanger, W.S. Cain and B.P. Leader. 1987. Stability of tobacco smoke odor in enclosed spaces. Proceedings of Indoor Air '87 : 4th International Conference on Indoor Air Quality and Climate..

PM3006517455

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Administration (OSHA) considers workplace exposure to more then 6.8 $\mu g/m^3$ as a significant risk [3].

III.3.6.2 A study of 25 work-sites (including offices) in Massachusetts shows that smoking permitted area has a considerable effect on nicotine concentrations (9.1$\mu g/m^3$ in closed office of non-smoker) than smoking restricted area (1.3 $\mu m/m^3$).[4]

III.3.6.3 Particles in tobacco smoke are especially hazardous because they remain airborne for a prolonged period, and attract radon decay products. Despite the controversies of the early investigations to identify a cause-and-effect relationship between passive smoking and respiratory cancer, a recent study concludes that 17% of lung cancers among non smokers can be attributed to high levels of exposure to ETS during childhood and adolescence[5].

III.3.6.4 A draft report by US Environmental Protection Agency (USEPA) concluded that "ETS is causally associated with lung cancer in non-smoking adults and that, according to USEPA guidelines, it is considered a "Group A" (known human) carcinogen and an estimated 3800 lung cancer deaths per year among non-smokers in the USA are due to ETS.

III.3.7 *Ozone*

III.3.7.1 Ozone (O_3) is an atmospheric oxidant formed through photochemical reactions of volatile organic compounds and nitrogen oxides.

III.3.7.2 Ozone is an irritant to the pulmonary system. It affects the mucous membranes and other lung tissues. It also affect respiratory function. At relatively low levels (60-120 ppb) which are more likely to occur in indoor premises, ozone may cause diminished lung function, cough, inflammation associated with biochemical changes and increased sensitivity to allergens[6]. It may be generated by equipment with ultra violet (UV) sources such as photocopiers in the office and is therefore measured as an indoor pollutant.

III.3.8 *Radon*

III.3.8.1 The main source of indoor radon is its immediate parent radium-226 in the ground of the sites and in the building materials. Radium (a member of the uranium decay series) is present in various concentrations in all rocks and soils. Radium decays to radon enters into the air or dissolves in water. Radon has a short half-life of less than four days. Radon further decays into a series of short-lives isotopes, radon daughters, that include: 218Po, 214Pb, 214Bi and 214Po. This series of decay products terminate with 214Po, a stable radionuclide with a half-life of about 22 years. Radon daughters have half-lives ranging from 1 second to 27 minutes. Radon is the highest single source of background radiation; other sources include cosmic rays and other naturally occurring radioactive matter.

III.3.8.2 A point to emphasise is that epidemiological data is scarce and most risk assessments for low dose of indoor radon are based upon extrapolations of observations from among high exposure mining population. Thus, the exposure /dose relationship of radon is extremely complex.

---

3 Hammond, S.K. Study Evaluates Nonsmoker Exposure to Nicotine in Workplaces. Indoor Air Quality Update. Vol. 8. No. 10. October 1995. pp. 7-8.

4 Hammond, S.K. Study Evaluates Nonsmoker Exposure to Nicotine in Workplaces. *Indoor Air Quality Update.* Vol. 8. No. 10. October 1995. pp. 7-8.

5 Janerich, D., Thompson, D. Varela, L. Greenwald, P. Chorost, S., Tucci, C. Zaman, M.Malemed, M. Kiely, M & McKneally, M. (1990). Lung Cancer and exposure to Tobacco Smoke in the Household. *N. Engl. J. Med.* 323: pp 632-36.

6 Boeniger, M., (1995), Report : Ozone Generators Not Effective, Pose Added Health Risk. *Indoor Air Quality Update.* Vol. 8. No. 9. September 1995. pp. 1-3.

PM3006517456

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

III.3.9 *VOCs*

III.3.9.1 In the past three decades, several hundreds different VOCs have been identified. USEPA (1989) detected and identified over 900 different VOCs in indoor environment[7]. At least 250 of these compounds regularly occur at levels greater than 1 ppb. which are usually 2 to 20 times greater than outdoor concentrations[8] which have been shown to be about 50 $\mu g/m^3$.

III.3.9.2 Building materials for structural and/or decoration such as wall, floor, and ceiling coverings and coatings may emit VOCs. Several authors (e.g., Burton[9] and Tucker[10]) have published information in this area.

III.3.9.3 Table III-1 and Table III-2 show the emission factors of various building materials and indoor VOCs emitted by wall and ceiling materials respectively:

---

7 United States Environmental Protection Agency (1989), *Report to Congress on Indoor Air Quality*, EPA Office of Air and Radiation/ Office of Research and Development (EPA/400/1-89/001).

8 Black, M.S., and Bayer, C.W., (1986), Formaldehyde and other VOC Exposures from Consumer Products, *Proceedings of ASHRAE IAQ '86 : Managing Indoor Air for Health and Energy Conservation*, pp. 454-68.

9 Burton, D.J. (1993) IAQ and HVAC Workbook. Utah, IVE, Inc.

10 Tucker, W.G., (1986). Research Overview : Source of Indoor Air Pollutants, *Proceedings of IAQ '86 : Managing Indoor Air for Health and Energy Conservation*, pp. 395-404.

PM3006517457

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table III-1 Emission Factors of Various Building Materials

Materials	Emission Factors (mg/m^3-hr)	VOC	Time of Test
Medium Density Fibreboard	0.7-2.3	HCHO	higher values are for newer materials
Hardwood plywood panelling	0.06-1.4	HCHO	
Particleboard	0.08-2.0	HCHO	
Urea-formaldehyde foam insulation	0.05-0.8	HCHO	
Softwood plywood	0.01-0.03	HCHO	
Paper products	0.01-0.03	HCHO	
Plywood	1.0	HCHO	"new"
Silicone Caulk	13	TVOC	<10 hrs
	<2	TVOC	10-100 hrs
Floor adhesive	220	TVOC	<10 hrs
	<5	TVOC	10-100 hrs
Floor wax	80	TVOC	<10 hrs
	<5	TVOC	10-100 hrs
Wood stain	10	TVOC	<10 hrs
	<0.1	TVOC	10-100 hrs
Polyurethane wood finish	9	TVOC	<10 hrs
	<0.1	TVOC	10-100 hrs
Floor varnish or lacquer	1	TVOC	<10 hrs
Particle board	0.2	TVOC	2 years old
Chipboard	0.1	TVOC	unknown
Gypsum board	0.03	TVOC	unknown
Wallpaper	0.1	TVOC	unknown

Source: Burton, D.J., 1993

III.3.9.4 Certain VOCs are given prominence because they are established or suspected carcinogens, e.g., benzene, formaldehyde and trichloroethylene.

PM3006517458

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table III-2 Indoor VOCs in Wall and Ceiling Materials

Compound	Formula	Substantiated Sources	Potential Sources
Formaldehyde	CH_2O	Plywood, particleboard, panelling, ceiling panels, urea foam insulation, wallpaper, caulking compounds, jointing compound, adhesive, fibreboard, chipboard, calcium silicate sheet, gypsum board	---
Benzene	C_6H_6	Adhesives, paint remover, particleboard	---
Trichloroethylene	C_2HCl_3	---	Solvent for paints and varnishes
Ethylbenzene	C_8H_{10}	Wall covering, insulation foam, chipboard, caulking compounds, jointing compound, fibreboard, calcium silicate sheet, adhesives	---
Toluene	C_7H_8	Solvent-based adhesive, water-based adhesive, edge sealing, moulding tape, wallpaper, jointing compound, calcium silicate sheet, vinyl coated wallpaper, caulking compounds, paint, chipboard	---
Xylenes	C_8H_{10}	Adhesives, jointing compound, wallpaper, caulking compounds, varnish	---
a = Source types for which quantitative data on emissions have been obtained in chamber tests, or for which quantitative data are available (e.g. from headspace testing).			
b = Source types known to contain the compound. Not all products of the source type will necessarily contain the compound			

Source: Tucker, 1986

III.3.9.5 Table III-3 shows the specific types of VOCs and their health effects[11].

Table III-3 VOC Emissions From Furnishings with A Number of Health Problems

VOC	Emission Sources	Health Effects
Benzene	Paints, stains, and varnishes used in furnishings	Respiratory tract irritation
Xylenes	Varnish and solvents for resins and enamels	Narcotic and irritant that can affect the heart, liver, kidney, and nervous system
Toluene	Chipboard	Narcotic and may cause anaemia
Trichloroethylene	Furniture varnishes	affect the central nervous system
Methylene chloride	Acoustical office partitions	A narcotic that can affect the central nervous system
2-Butanone	Fibreboard and particleboard	An irritant and central nervous system depressant
Tetrochloroethylene	Dry-cleaned fabrics and draperies	An irritant to the skin and eyes, and can induce central nervous system depression

[11] United States Environmental Protection Agency/ United States Public Health Service/ National Environmental Health Association, (1991), *Introduction to Indoor Air Quality : A Reference Manual* EPA/400/3-91/003, 297 pp.

PM3006517459

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

III.3.10 *Biological Pollutants*

III.3.10.1 Biological pollutants typically are brought into the building by ventilation systems or natural air exchange. Dirt and moisture that accumulate in MVAC systems provide a breeding ground for biological pollutants. In buildings, micro-organisms are generally found on surfaces (such as carpet, ceiling and tiles) or floating on dust/aerosol particles.

III.3.10.2 Of the airborne bio-contaminants, the ones generally found in indoor environments are: viruses, bacteria (e.g. *Pseudomonas, Staphylococcus*), antinomycetes (e.g. *Mycobacterium*) and fungi (e.g. *Penicillium, Aspergillus, Cladosporium* and *Candida*).

III.3.10.3 Bio-contamination is common in HVAC system, particularly where stagnant water accumulates, such as humidifiers, drip pans and drain pans. Moisture accumulation on dusty units, induction units and cooling coils can turn these components into microbial reservoirs[12].

III.3.10.4 Human have to contend with the vast number of microbes every day. However, the exposure to these microbes may not necessarily result in overt clinical manifestations because of the immune system. Yet, microbial contamination in air can cause illness through infection or allergic reaction. Common infections caused by airborne organisms include Legionnaire's disease, colds, and influenza.

III.3.11 *Mycotoxins*

III.3.11.1 Mycotoxins are biologically the most potent of agents in moulds and mycotoxin contamination has been demonstrated in homes containing Aspergillus fumigatus[13]. Stachybotrus atra is a hydrophilic mould that can produce highly toxic macrocyclic trichothecenes. Mycotoxins producing fungi are not uncommon in residential buildings.

III.4 The Consequences of Inadequate Control on IAQ

III.4.1 Indoor air pollution can become particularly serious when ventilation rates are insufficient to dilute airborne contaminants. This is the direct result of insufficient air exchange rates. The normal design factor for office layout is 9 m^2 per person. In Hong Kong where rental rates are possibly the highest in the world, such a requirement is rarely achieved. Even if it can be achieved on an overall basis, space tend to be unevenly distributed. For example, workstations are usually crowded together. The effectiveness of ventilation in these areas would be greatly reduced. However, VOC emissions from building materials/ office furnishings/ materials tend to be higher initially at higher air exchange rates, but this causes the source to be depleted more quickly.

III.4.2 General building maintenance affects the sustainability of building quality. The maintenance programme for buildings should include preventive maintenance and up keep of the building works and interior decorations and installations. The maintenance works should include water proofing, sealing effect of windows and doors and any infiltration through basement structure. Moisture accumulation due to water leakage and seepage causes microbial growth and would cause discomfort or even allergic or toxigenic reactions in the occupants.

---

12 Morey, P.R., (1988), Microorganisms in buildings and HVAC systems : A summary of 21 environmental studies. Proceedings of the ASHRAE Conference IAQ '88 : Engineering Solutions to Indoor Air Problems. pp. 10-24.

13 Miller, J.D., et. al., (1988), "Fungi and Fungal Products in some Canadian Houses", Int Biodeterior Bull 1988, 24:103.

PM3006517460

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

III.4.3 Poor building services, for example, lack of proper maintenance of the air conditioning systems may lead to outbreak of Legionnaire's disease (a notifiable disease) due to the growth of the Legionella bacteria on the drip pans in air condition ducts. Inefficient filtering due to poor fitting or overloaded filter have also caused poor indoor air quality.

III.4.4 Regular cleaning of soft furnishing including carpets is important to remove accumulated dust, adsorbed organic, moulds, spores and other pests. These agents were found to be culprits in causing building related discomforts and illnesses.

PM3006517461

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX IV

Questionnaire for Telephone and On-site Survey

PM3006517462

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX IV

Questionnaire for Telephone and On-site Survey

PM3006517463

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

室內空氣質素調查

58116

請按照以下規則完成此問卷

- 除非題目指明，每題只可以選擇一個答案。
- 請用黑色原子筆將適當之圓圈完全塗黑。
- 請按右圖所示，將適當答案之圓圈完全塗黑： ● 正確

  錯誤方法 ◔ ◉ ⊗ ✓ 不正確
- 如果填錯圓圈，請將錯誤的圓圈劃去，再塗黑正確之圓圈，如下圖所示：

  ✗ ○ ○ ● ○
- 如果答案是二十九，請按照以下的方法塗黑圓圈。

  ① ● ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

  ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ● ⑩
- 如果答案是六，請按照以下的方法塗黑圓圈。

  ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ●

  ① ② ③ ④ ⑤ ● ⑦ ⑧ ⑨ ⑩
- 請勿使用塗改液。

Office use only:

01 Building ID:

02 Area ID:

03 Date of Survey: MM / DD / YY

04 HVAC ID:

05 Building age:

06 Office class:

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

第一部份：

1 你每日有多少個鐘頭會在寫字樓工作？ 鐘頭一日

2 你每星期有多少日會留在寫字樓工作？

0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7

日一週

有 沒有

3 你有沒有自己的固定工作位置？

第二部份：

男性 女性

4 被訪者是：

5 你幾多歲？ 歲

小學程度或以下 中學程度 大學程度或以上

6 你的教育程度是？

從來不抽 從前曾經抽 現在抽

7 你抽不抽煙？

非常 可以接受 沒有影響

8 你覺得二手煙對你影唔影響？

9 吸煙者：你會否工作時抽煙？ 會，工作時每日 支

不會

10 吸煙者：你每日總共抽多少支煙？ 支一日

需要 有時 不需要

11 工作時你需要戴隱形眼鏡嗎？

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

58118

12 你在這一間大廈工作了多少年？ [redacted] 年

若少過一年，工作了多少個月？ [redacted] 月

老闆或董事或合夥人　僱員（月薪）　僱員（週或時薪）

13 你的職業狀況是？ [redacted]

滿意　不滿意　無意見

14 你對最近一次的加薪幅度或花紅滿意嗎？ [redacted]

15 你對現時的工作滿意嗎？

16 你有另一份工作嗎？ [redacted] 有，平均每週 [redacted] 小時

無

無意見

17 你的工作性質是？（請選一項） [redacted]

管理人員
專業人員
技術人員
秘書或文員
接待員
售貨員
其它（請列明）

18 你每日大約會用電腦多少個小時？（如不及一小時亦作一小時計） [redacted] 小時一日

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

你是否曾被診斷或觀察有以下的病症？

	否	是（並由醫生證實）	在現時工作的寫字樓工作時發病，並經醫生診斷 否	是
19 哮喘	○	○	○	○
20 花粉症或對花粉敏感	○	○	○	○
21 支氣管炎	○	○	○	○
22 皮膚病	○	○	○	○
23 不知起因的感冒	○	○	○	○
24 對塵蟎敏感	○	○	○	○
25 對霉菌敏感	○	○	○	○

26 你需不需要超時工作？ ○ 不要 ○ 要，平均每週 [redacted] 小時

27 當你超時工作時，寫字樓內有那一種通風設施提供？
- ○ 中央冷氣系統
- ○ 窗口機冷氣
- ○ 窗
- ○ 電風扇
- ○ 分體式冷氣
- ○ 完全沒有

第三部份：

28 公司位於那一區：

港島西區
- ○ 上環
- ○ 中環
- ○ 灣仔
- ○ 銅鑼灣
- ○ 北角/鰂魚涌
- ○ 港島其他地區

九龍
- ○ 尖沙咀
- ○ 油麻地
- ○ 旺角
- ○ 長沙灣
- ○ 官塘
- ○ 九龍其他地區

新界
- ○ 荃灣
- ○ 沙田
- ○ 新界其他地區

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

58116

29 你寫字樓在那一層樓？

樓

可以　不可以　不知道

30 你可不可以對溫度　濕度作出調較？

中央冷氣　窗口機　分體式冷機　完全沒有

31 你寫字樓安裝了什麼類形的冷氣機系統？

有　無　不知道

32 你寫字樓有沒有空氣淨化裝置？

33 若有，那一種？

- 靜電除塵器
- 臭氧消毒
- 負離子機
- 空氣清新機
- 高效率隔塵網
- 不知道

有　無　沒有特別感覺

34 若有，你覺得空氣質素有沒有改善？

35 以下那一句最適合形容你的固定工作位置：

- 私家單人房
- 共用房間（10人以下）
- 開放式有隔板
- 開放式無隔板
- 其它（請列明）：

擠迫　尚可　寬敞

36 你怎樣形容你的工作位置？

多食　少食　小食　不食

37 你有沒有在自己的工作位置吃東西？

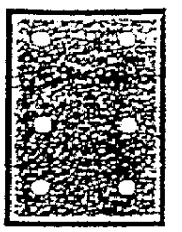
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

有　無

38 你有否在寫字樓用煮食工具例如微波爐,飯煲等?

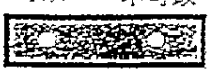
39 若有，公司有沒有茶房放置這些煮食工具？

40 你固定工作位置附近有無可打開的窗?



可以　不可以

41 若有，你可不可以開窗？



經常　有時　無

42 你有沒有發覺公司內的出風口有很多塵？

有　無

43 你工作位置有沒有地氈？

44 你公司的吸煙政策是？

公司內完全冶吸煙

寫字樓範圍內不准吸煙

只准在特定房間或範圍內吸煙

只准在走廊通道或廁所內吸煙

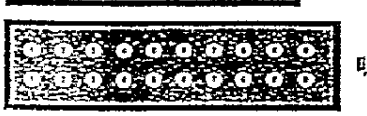
是　否

45 你公司的吸煙政策是否嚴格實施？

有　無　不知道

46 你工作位置附近有無吸煙者？

47 若有，多少個？



吸煙者

有　無

48 他們有沒有在工作位置內吸煙？

PM3006517469

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

58116

第四部份：

過去三個月，在你工作位置三米範圍內有沒有以下的事情發生？

	有	沒有	不知道
49 換新地氈			
50 油漆油髹			
51 換新牆紙			
52 換新傢俬			
53 換新隔板			
54 漏水情形			

以下物件，距離你的工作位置多遠？

	三米以內	三米以外	在另一個房間
55 影印機			
56 鐳射打印機			
57 傳真機			

工作時，你需要用以下物件嗎？

	多於一日一次	少於一日一次	少用或不用
58 塗改液			
59 箱頭筆			
60 噴膠			
61 萬能膠			
62 過底紙			

PM3006517470

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

第五部份：

a. 過去四星期當你在寫字樓工作時，有沒有感到以下的症狀？		b. 過去四星期工作時，當你離開寫字樓後（包括週末或放假）這些症狀有怎麼變化？		
症狀	頻密度（每週多少日）	好	無變	差
63 眼乾，眼痕癢或流眼水		○	○	○
64 流鼻水		○	○	○
65 鼻塞		○	○	○
66 易患炎		○	○	○
67 喉痛或乾		○	○	○
68 咳嗽		○	○	○
69 喘氣或運動時喘息		○	○	○
70 氣促或呼吸有困難		○	○	○
71 打噴嚏		○	○	○
72 有痰		○	○	○
73 作嘔		○	○	○
74 頭痛		○	○	○
75 頭暈		○	○	○
76 皮膚乾或痕癢		○	○	○
77 皮膚紅疹		○	○	○
78 異常疲倦，疲泛		○	○	○
79 記憶或精神集中有困難		○	○	○
80 胃不適或胃痛		○	○	○
81 肌肉痛		○	○	○
82 腹瀉		○	○	○
83 有記錄的發燒		○	○	○

84 過去一個月內，你有多少次感冒或感冒？ ○○○○○○○○○○ 次

你總共不舒服了多少天？ ○○○○○○○○○○ 天

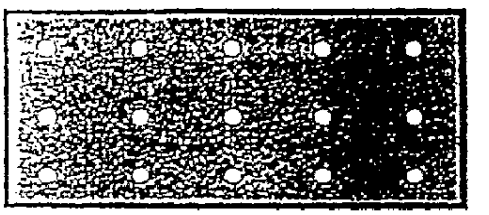
85 過去一個月內，你請過多少天病假？ ○○○○○○○○○○ 天

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

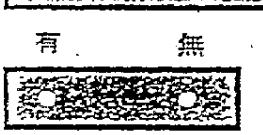
58116

第六部份：

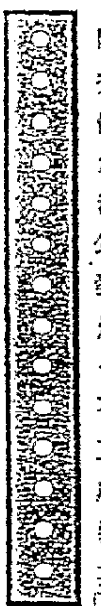
	非常滿意	滿意	普通	不滿意	非常不滿意
86 你認爲你寫字樓的空氣質素如何？					
87 你認爲你寫字樓的舒適程度如何？					
88 你認爲你寫字樓的清潔程度如何？					



	有	無
89 過去三個月，你有沒有覺得在你工作範圍內有異味？		

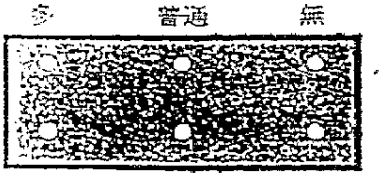


90 若果有，異味是否由以下的項目產生：

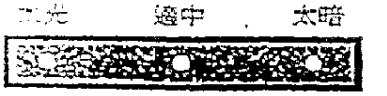


- 附近酒樓的煙囪
- 交通廢氣
- 體臭
- 燒香氣味
- 清潔劑
- 公司內廚房或煮食設施
- 發霉氣味
- 煙味
- 化學品氣味
- 不知明氣味來源
- 工廠
- 鄰居煮飯
- 裝修
- 其他（請列明）：

	多	普通	無
91 你的工作位置多不多塵？			
92 你的工作位置嘈不嘈？			



	太光	適中	太暗
93 你的工作位置光線如何？			



Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

你的雙眼有無以下的症狀？

無　返工前　工作中　夜晚

94　乾
95　灼熱
96　流眼水
97　眼瞓

98　你用不用眼藥水來減低不適？

次一日

不用 ☐

經常　有時　不會　不知道

99　你有沒有覺得這些症狀是由於公司的室內空氣所引起？

你的工作位置的溫度如何？

太凍　適中　太熱

100　夏天：
101　冬天：

你的工作位置的濕度如何？

太乾燥　適中　太潮濕

102　夏天：
103　冬天：

你的工作位置的通風狀況如何？

太大風　滿意　太悶

104　夏天：
105　冬天：

第七部份：

星期一至五　週末或假期　無定時

106　你通常會什麼時候去商場？

很差　一般　很好　無意見

107　一般來說，你覺得大部份商場的室內空氣質素怎樣？

108　那一個商場的空氣質素是你到過的最差的一個？ ☐ 無特別一個

商場名：　　地區：

很差　一般　很好　無意見

109　一般來說，你覺得大部份酒樓的室內空氣質素怎樣？

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

58118

110 那一間酒樓的室內空氣質素是你到過的最差一間？ ☐ 無特別一間

酒樓名：＿＿＿＿＿＿ 地區：＿＿＿＿＿＿

	很差	一般	很好	無意見
111 你覺得你到過的戲院一般空氣質素點樣？	○	○	○	○

112 請講出一個你所到過的空氣質素最差的其他公共場所

＿＿＿＿＿＿（有冷氣系統的地方）

	有，在平台	有，在車廂內	無
113 你有沒有曾經搭地鐵時感到頭暉？	○	○	○

你對以下的說話有什麼意見：

	非常同意	同意	無意見	不同意	非常不同意
114 一個舒適的工作環境可以增加生產力	○	○	○	○	○
115 僱主有責任提供一個好的工作環境	○	○	○	○	○
116 僱員亦都要為一個滿意工作環境出一分力	○	○	○	○	○
117 若果公司的環境質素有問題，一般老闆會很願意和設法盡快去解決問題	○	○	○	○	○
118 政府應立例禁止在寫字樓及室內的公共場所吸煙	○	○	○	○	○
119 政府應很願參與訂立樓宇守則（例如冷氣系統的標準）以改善室內空氣質素	○	○	○	○	○

120 你認為那一個政府部門應主力負責有關室內空氣質素的問題？

- ○ 環境保護署
- ○ 建築署
- ○ 機電工程署
- ○ 衛生署
- ○ 勞工署
- ○ 其他（請列明）

＿＿＿＿＿＿

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Consultancy for Indoor Air Pollution in Offices and Public Places in Hong Kong
Agreement No. CE 14/95

QUESTIONNAIRE SURVEY

SECTION A

i. You work in a :	O Commercial Building O Industrial Building O Industrial / Office Building O Others_____
ii. How many HOURS PER DAY do you stay in your office?	__ hours/day
iii. How many DAYS PER WEEK do you stay in your office?	__ day(s)/week
iv. Do you have air conditioning system at your workplace ?	O Yes O No O Don't know
v. How many occupants are there working at the same floor as yours?	__ people O Less than 25 O 25 to 50 O More than 50 O Don't know
vi. Do you have your own workstation at your office ?	O Yes O No
* For this questionnaire, your "workstation" is the place (desk, cubicle, office, etc.) where you do the majority of your work	

SECTION B : PERSONAL INFORMATION

The interviewee is:	O Male O Female
1. How old are you ?	__ years old O Under 21 O 21-30 O 31-40 O 41-50 O 51-60 O Over 60
2. What is the highest level of school attended?	O Primary School or less O Secondary School O Tertiary
3. What is your tobacco smoking status?	O Never Smoked O Former Smoker O Current Smoker
3a. For non-smokers / ex-smokers, does tobacco smoke bother you ?	O A lot O OK O Not at all
3b. For smokers, do you smoke at work ?	O Yes, __ cigarette/day at work O No
3c. For smokers, total no. of cigarettes per day ?	__ cigarette/day
4. Do you need to wear contact lenses while at work?	O Yes O Occasionally O No
5. How long have you worked in this building, to the nearest year ?	__ __ years
If less than one year, how many months have you worked in this building ?	__ __ months
6. What is your employment status ?	O Business Owner/Director / Self-employed O Employee (monthly paid) O Employee (weekly/hourly paid)
7. Are you satisfied with your last pay rise / bonus ?	O Yes O No O No comment
8. Are you satisfied with your job ?	O Yes O No O No comment

PM3006517475

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

9. Do you have a second job? O Yes, on average __ __ hours/week O No O No comment

10. What is your job nature ?
O Managerial O Professional O Technical O Secretarial or Clerical O Receptionist
O Sales Person O Other (specify) _____

11. About how many Hours Per Day do you work with a computer or word processor, to the nearest hour ?
__ __ hours per day

12. Were you ever diagnosed/observed to have the following ?

	No	Yes (but not diagnosed by doctor)	Diagnosis made by a doctor, and during times working at this office	
Asthma	O	O	O Yes	O No
Hay fever/allergy to pollen	O	O	O Yes	O No
Bronchitis	O	O	O Yes	O No
Dermatitis	O	O	O Yes	O No
Episodes of unexplained flu	O	O	O Yes	O No
Allergy to dust mites	O	O	O Yes	O No
Allergy to moulds	O	O	O Yes	O No

13. Do you work overtime? O Yes O No If Yes, on average __ __ hours per week.

14. When you work overtime, what type of ventilation facility is provided?
O Central Air Conditioning O Window AC O Window
O Mechanical Fan O Split AC Unit O Nothing

SECTION C : WORKPLACE CONDITION

15. What is the name of the building and the street you are working in?
Building: _____ Street Name: _____

16. The building is located in :

O Island West	O Tsim Sha Tsui	O Tsuen Wan
O Sheung Wan	O Yau Ma Tei	O Sha Tin
O Central	O Mong Kok	O Other part of N.T.
O Wan Chai	O Cheung Sha Wan	
O Causeway Bay	O Kwun Tong	
O North Point / Quarry Bay	O Other part of Kowloon	
O Other part of HK Island		

17. What floor is your office located on ? __ Floor

18. What type of air conditioning system is installed in your office? O Central O Window Unit O None

PM3006517476

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

19. Is there any air cleaning device installed in your office? O Yes O No O Don't know

19a. If yes, what type ? O Electrostatic precipitator O Negative ion generator O HEPA filter
O Disinfection (ozone) O Odour removal/masking O Don't know

19b. If yes, do you recognise any improvement ? O Yes O No O Don't know

20. Which of the following best describes the space in which your current workstation is located ?
O Single person private office O Shared private office (less than 10 staff)
O Open space with partitions O Open space without partitions O Other (specify) _____

21a. How big is your office? ____ ft^2 or ____ m^2

21b. Your working space is : O Crowded O OK O Spacious

22a. Do you eat at your workstation ? O Breakfast O Lunch O Snacks O Never

22b. Do you use cooking utensils eg. Microwave oven, rice cooker in your office? O Yes O No
If Yes, do you have a pantry for the cooking utensils? O Yes O No

23. Is there an openable window near your workstation? O Yes O No
If yes, can you open the window as you wish? O Yes O No

24. Do you observe/experience that in your office the air defusers have large amount of dust?
O Often O Occasionally O Never

25. Is there carpet at your workstation? O Yes O No

26. What is the Smoking Policy of your office?
O Smoking is permitted within the office
O Smoking is NOT permitted within my workplace
O Smoking is permitted ONLY in specific cordoned off room/area in office
O Smoking is permitted ONLY at corridors/toilets

27. Is the Smoking Policy properly enforced? O Yes O No

28. In the room of your workstation, are there smokers ? O Yes O No O Don't know

28a. If yes, how many ? __ smokers

28b. Do they smoke in the room? O Yes O No

PM3006517477

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

SECTION D : WORKPLACE OPERATION/EQUIPMENT

29. During the PAST 3 MONTHS, have the following changes taken place within 3 m of your workstation ?

29a. New carpeting	O Yes	O No	O Don't know
29b. Walls painted	O Yes	O No	O Don't know
29c. New wall covering	O Yes	O No	O Don't know
29d. New furniture	O Yes	O No	O Don't know
29e. New partitions	O Yes	O No	O Don't know
29f. Water damage	O Yes	O No	O Don't know

30. Among the following list of items, how far are they located from your workstation?

	Within 3m	More than 3m	In a different room
30a. Photocopier	O	O	O
30b. Laser printer	O	O	O
30c. Fax machine	O	O	O

31. Do you work with the following ?

	More than Once/day	Less than Once/day	Rarely/ Never
31a. Correction fluid	O	O	O
31b. Marker pen	O	O	O
31c. Spray adhesive	O	O	O
31d. Solvent Glue	O	O	O
31e. Carbonless Paper	O	O	O

PM3006517478

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

SECTION E : INFORMATION ABOUT HEALTH AND WELL-BEING

32a. During the LAST FOUR WEEKS YOU WERE AT WORK, how often have you experienced each of the following symptoms while working in this building?		32b. During the LAST FOUR WEEKS YOU WERE AT WORK, what happened to this symptom at times WHEN YOU WERE AWAY FROM WORK? (e.g. Holidays, weekends)		
SYMPTOMS	Occurrence Frequency	Got Better (1)	Stayed Same (2)	Got Worse (3)
Dry, itching, or watery eyes	__ days/week	O	O	O
Runny nose (Rhinitis)	__ days/week	O	O	O
Stuffy nose	__ days/week	O	O	O
sinus congestion (Mucous membrane inflammation)	__ days/week	O	O	O
Sore or dry throat	__ days/week	O	O	O
Cough	__ days/week	O	O	O
Wheezing/ asthmatic attack during exercise	__ days/week	O	O	O
Shortness of breath/ difficulty in breathing	__ days/week	O	O	O
Sneezing	__ days/week	O	O	O
Sputum/ phlegm	__ days/week	O	O	O
Nausea	__ days/week	O	O	O
Headache	__ days/week	O	O	O
Dizziness	__ days/week	O	O	O
Dry or itchy skin	__ days/week	O	O	O
Redness, heat of skin	__ days/week	O	O	O
Unusual tiredness, fatigue or drowsiness	__ days/week	O	O	O
Difficulty remembering things or concentrating	__ days/week	O	O	O
Stomach upset/pain	__ days/week	O	O	O
Muscle pain	__ days/week	O	O	O
Diarrhoea	__ days/week	O	O	O
Documented fever	__ days/week	O	O	O
33. In the last 30 days, how many bouts of cold/flu did you get? __ no. of bouts		How many days in total did you suffer from it?		__ days
34. How many days of sick leave have you taken over the past 30 days ? __ days				

PM3006517479

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

SECTION F : OCCUPANT'S PERCEPTION OF WORKPLACE ENVIRONMENT

35. How would you rate the air quality of your office? O V.Good O Good O Fair O Poor O V. Poor

36. How would you rate the comfortness of your office? O V.Good O Good O Fair O Poor O V. Poor

37. How would you rate the cleanliness of your office? O V.Good O Good O Fair O Poor O V. Poor

38. Do you observe/experience any odour problem in your own workspace during the last 3 months?

O Yes O No

If Yes, is the source originated from any of the following :

O Chimney of a restaurant in the vicinity O In-house kitchen/ cooking facilities

O Traffic emission O Mouldy smell O Factory

O Body odour O Tobacco smoke O Neighbours' cooking

O Incense O Chemical smells O Building renovation/remodelling

O Cleaning components O No idea about the source O Others (specify)_____

39. Do you have any dust-problem in your own workspace ? O Some O Little O None

40. Do you experience any noise problem in your own workplace ? O Some O Little O None

41. Do you have any lighting problem in your own workspace? O Too bright O Too dim O Just right

42. Do you have any of the following symptoms of your eyes?

	Before work	During work	At night
Dryness	O	O	O
Burning	O	O	O
Tearing	O	O	O
Filming	O	O	O

42a. Do you use eyedrops to alleviate the discomfort? __ times/workday O No

42b. Do you feel these are caused by the air at work?

O Always O Sometimes O Never O Don't know

43. What is the thermal condition / temperature of your workspace?

43a. In summer : O Too cold O OK O Too hot

43b. In winter : O Too cold O OK O Too hot

44. What is the humidity condition of your workspace?

44a. In summer : O Too dry O OK O Too humid

44b. In winter : O Too dry O OK O Too humid

45. What is the ventilation condition of your workspace?

45a. In summer : O Too draughty O OK O Too stuffy

45b. In winter : O Too draughty O OK O Too stuffy

PM3006517480

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

SECTION G : SUPPLEMENTARY QUESTIONS

46. When do you normally go to a Shopping Centre/Mall? O Weekdays O Weekends/Holidays

47. In general, how do you find the air quality of the Shopping Mall you have visited before ?
O Satisfactory O Not Satisfactory O No Comment

48. Please name the WORST Shopping Mall you have ever visited
Name: _____ District _____ O Cannot specify one

49. In general, how would you rate the air quality of most indoor restaurants you have visited?
O V. Poor O Poor O OK O Good O V. Good O No Comment

50. Please name the WORST Restaurant you have ever visited
Name: _____ District _____ O Cannot specify one

51. In general, how do you find the air quality of the Cinemas you have visited before?
O V. Poor O Poor O OK O Good O V. Good O No Comment

52. Please specify any other public places with WORST air quality you have ever visited.
_____ (with mechanical ventilation system only)

53. Have you ever felt dizzy in the MTR? O Yes, on platform O Yes, in train compartment O No

54. Do you travel on MTR to work? O Yes O No
If Yes, you normally travel from _____ station to _____ station to work.

55. Do you Support the following statements:

		Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
a.	A healthy working environment would increase productivity.	O	O	O	O	O
b.	It is the employer's responsibility to provide a good workplace environment.	O	O	O	O	O
c.	Employees should also contribute efforts to a satisfactory workplace environment.	O	O	O	O	O
d.	If we had workplace environmental problem, our employer would willingly & promptly respond to solve the problem.	O	O	O	O	O
e.	Smoking should be prohibited by law in all offices and public places (indoors).	O	O	O	O	O
f.	Government should be actively involved in establishing building codes - ventilation rates, design standards to improve indoor air quality	O	O	O	O	O

56. Which government department(s) do you think is responsible for indoor air quality problem ?
O Architectural Services Dept O Environmental Protection Dept O Electrical & Mechanical Services Dept
O Dept. of Health O Labour Dept O Others _____

57. Can you recommend a telephone number of one of your colleagues for our survey ?
O Yes Tel.: _____ O No

PM3006517481

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX V

Results of the Telephone Survey and On-site Questionnaire Survey

PM3006517482

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

I. Results Of The Telephone And On-Site Questionnaire Survey

There are two sections to this appendix. The first section is the tabulation of the results obtained from the Telephone Survey (TS) and On-site Questionnaire Survey (OQS), and the tabulation by frequency distribution is shown in the second section.

Section 1 : Frequency Distribution of TS and OQS

A. Number of Working Hours per Day and Number of Workdays per Week

Table 1-1 Working Hours Within the Office Premises

Working Hours per day	TS		OQS	
	Count	Percentage	Count	Percentage
≤ 4	15	0.75	6	0.52
5	29	1.45	10	0.87
6	56	2.80	11	0.95
7	126	6.31	72	6.23
8	1273	63.75	547	47.36
9	355	17.78	379	32.81
10	111	5.56	101	8.74
11	7	0.35	18	1.56
12	19	0.95	10	0.87
≥ 13	6	0.3	1	0.09
Total	1997	100.00	1155	100.00

Table 1-2 Working Days Within the Office Premises

Working Days per week	TS		OQS	
	Count	Percentage	Count	Percentage
2	1	0.05	4	0.35
3	7	0.35	5	0.43
4	18	0.90	11	0.95
5	1047	52.25	361	31.20
6	908	45.31	752	65.00
7	23	1.15	24	2.07
Total	2004	100.00	1157	100.00

B. Gender of Respondents

Table 1-3 Gender of Respondents

Sex	TS		OQS	
	Count	Percentage	Count	Percentage
Male	964	48.03	495	42.75
Female	1043	51.97	663	57.25
Total	2007	100.00	1158	100.00

PM3006517483

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

C. Age of Respondents

Table I-4 Age of Respondents

Age	TS		OQS	
	Count	Percentage	Count	Percentage
Under 22	132	7.11	38	3.35
22-25	315	16.96	287	25.26
26-30	518	27.90	292	25.70
31-35	320	17.23	224	19.72
36-40	303	16.31	169	14.88
41-45	116	6.25	60	5.28
46-50	87	4.69	38	3.35
51-55	33	1.77	15	1.32
56-60	22	1.19	7	0.61
Over 60	11	0.59	6	0.53
Total	1857	100.00	1136	100.00

D. Education Level and Occupation of Respondents

Table I-5 Education Level of Respondents

Education Level	TS		OQS	
	Count	Percentage	Count	Percentage
Primary or Below	30	1.52	7	0.61
Secondary	1154	58.37	637	55.15
Matriculation or above	793	40.11	511	44.24
Total	1977	100.00	1155	100.00

Table I-6 Occupation of Respondents

Education Level	TS		OQS	
	Count	Percentage	Count	Percentage
Manager/Executive	321	16.19	113	9.80
Professional	389	19.62	318	27.58
Semi-professional	90	4.54	87	7.55
Clerk/Secretary/ Receptionist	984	49.62	570	49.44
Service worker/Sales	149	7.52	7	0.61
Craftsman	10	0.50	57	4.94
Others	40	2.01	1	0.09
Total	1983	100.00	1153	100.00

PM3006517484

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

E. Education Level and Occupation of Respondents

Table I-7 Respondent's Perception on IAQ Comfortness/Cleanliness

Response	TS						OQS					
	IAQ		Comfort		Cleanliness		IAQ		Comfort		Cleanliness	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Very satisfied	39	1.94	29	1.45	45	2.25	8	0.69	8	0.69	9	0.78
Satisfied	897	44.69	1040	51.90	1176	58.74	127	10.96	202	17.49	253	21.90
OK	515	25.66	598	29.84	511	25.52	572	49.35	644	55.76	570	49.35
Dissatisfied	498	24.81	303	15.12	231	11.54	326	28.13	243	21.04	258	22.34
Very dissatisfied	38	1.89	18	0.90	26	1.30	122	10.53	58	5.02	65	5.63
Refuse	20	1.00	16	0.80	13	0.65	4	0.35	0	0.00	0	0.00
Total	2007	100.00	2004	100.00	2002	100.00	1159	100.00	1155	100.00	1155	100.00

F. Odour Experienced at Work for the Past Three Months

Table I-8 Sources of Odour Identified by the Respondent

Sources of Odour	TS		OQS	
	Count	Percentage	Count	Percentage
Chimney of restaurant	11	2.98	22	2.60
Kitchen	10	2.71	80	9.45
Traffic emission	10	2.71	11	1.30
Mouldy smell	16	4.34	100	11.81
Factory emission	18	4.88	2	0.24
Body odour	4	1.08	72	8.50
Tobacco smoke	48	13.01	114	13.46
Neighbour cooking	1	0.27	16	1.89
Incense	5	1.36	12	1.42
Chemicals	14	3.79	33	3.90
Building renovation	30	8.13	95	11.22
Cleaning components	6	1.63	85	10.04
Others	82	22.22	27	3.19
Don't know	114	30.89	178	20.98
Total	369	100.00	847	100.00

PM3006517485

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

G. Dust / Noise / Lighting Problem at Work

Table I-9 Respondent's Perception on Dust/Noise/Lighting Problems at Work

Response	TS						OOS					
	Dust		Noise		Lighting		Dust		Noise		Lighting	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Some	453	22.65	231	11.56	62	3.10	345	29.84	228	19.72	38	3.29
Little	666	33.30	389	19.47	1821	91.19	689	59.60	707	61.16	1031	89.26
None	867	43.35	1370	68.57	101	5.06	122	10.55	221	19.21	86	7.45
Don't know /Refuse	14	0.70	8	0.40	13	0.65	0	0.00	0	0.00	0	0.00
Total	2000	100.00	1998	100.00	1997	100.00	1156	100.00	1156	100.00	1155	100.00

H. Temperature / Humidity / Ventilation in the Office

Table I-10 Respondent's Perception on Temperature in the Office

Response	TS				OOS			
	Summer		Winter		Summer		Winter	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Too Cold	405	20.29	361	18.12	314	27.19	264	23.43
OK	1329	66.58	1498	75.20	605	52.38	774	68.68
Too Hot	188	9.42	97	4.87	236	20.43	89	7.90
Don't know / refuse	74	3.71	36	1.81	0	0.00	0	0.00
Total	1996	100.00	1992	100.00	1155	100.00	1127	100.00

PM3006517486

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table I-11 Respondent's Perception on Humidity in the Office

Response	TS				OQS			
	Summer		Winter		Summer		Winter	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Too Dry	148	7.42	199	9.99	193	16.72	248	22.06
OK	1701	85.31	1698	85.24	928	80.42	871	77.49
Too Humid	61	3.06	43	2.16	33	2.86	5	0.44
Don't know / refuse	84	4.21	52	2.61	0	0.00	0	0.00
Total	1994	100.00	1992	100.00	1154	100.00	1124	100.00

Table I-12 Respondent's Perception on Ventilation in the Office

Response	TS				OQS			
	Summer		Winter		Summer		Winter	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Too Draughty	68	3.41	55	2.76	126	10.91	118	10.45
OK	1490	74.76	1572	78.92	621	53.77	734	65.02
Too Stuffy	369	18.51	335	16.82	408	35.32	277	24.53
Don't know / refuse	66	3.31	30	1.51	0	0.00	0	0.00
Total	1993	100.00	1992	100.00	1155	100.00	1129	100.00

PM3006517487

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

I. Respondent's Smoking Status

Table I-13 Respondent's Smoking Status

Smoking Status	TS		OQS	
	Count	Percentage	Count	Percentage
Current smoker	250	12.57	71	6.14
Former smoker	27	1.36	84	7.26
Never smoke	1709	85.92	1002	86.60
Don't know / refuse	3	0.15	0	0.00
Total	1989	100.00	1155	100.00

Table I-14 Smoke at Work

Smoke at Work	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	97	34.40	34	10.46
No	176	62.41	291	89.54
Don't know / refuse	9	3.19	0	0.00
Total	282	100.00	325	100.00

Table I-15 Tobacco Smoke Bothers

Response	TS		OQS	
	Count	Percentage	Count	Percentage
A lot	1267	74.05	911	78.81
OK	289	16.89	217	18.77
Not at all	110	6.43	28	2.42
Don't know / refuse	45	2.63	0	0.00
Total	1711	100.00	1156	100.00

Table I-16 Respondent's Smoking Habit

No. of Cigarettes	TS				OQS			
	Cigarette at work per day		Cigarette per day		Cigarette at work per day		Cigarette per day	
	Count	%	Count	%	Count	%	Count	%
0	2	2.27	8	3.32	1123	96.89	1088	93.87
1	1	1.14	6	2.49	0	0.00	1	0.09
2	4	4.55	27	11.20	1	0.09	4	0.35
3	6	6.82	16	6.64	6	0.52	5	0.43
4	4	4.55	10	4.15	5	0.43	1	0.09
5	10	11.36	23	9.54	6	0.52	13	1.12
6-10	32	36.37	75	31.12	15	1.29	28	2.43
11-15	10	11.37	30	12.44	1	0.09	9	0.78
16-20	15	17.05	31	12.86	1	0.09	6	0.52
21-30	2	2.27	22	4.97	0	0.00	1	0.09
40	2	2.27	3	1.24	1	0.09	3	0.27
Total	88	100.00	241	100.00	1159	100.00	1159	100.00

251

PM3006517488

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

J. Respondent's Working Habit

Table I-17 Wear Contact Lenses at Work

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	317	15.95	282	24.52
Occasionally	77	3.87	58	5.04
No	1589	79.93	810	70.43
Don't know / refuse	5	0.25	0	0.00
Total	1988	100.00	1150	100.00

Table I-18 No. of Hours per day Using Computer/Word Processor at Work

No. of Hours	TS		OQS	
	Count	Percentage	Count	Percentage
0	3	0.23	103	8.93
1	208	15.83	187	16.20
2	194	14.76	117	10.14
3	179	13.62	113	9.79
4	162	12.33	101	8.75
5	144	10.96	107	9.27
6	132	10.05	99	8.58
7	65	4.95	102	8.84
8	170	12.94	144	12.48
Over 8	57	4.34	81	7.02
Total	1314	100.00	1154	100.00

Table I-19 No. of Months Working in this building

No. of Months	TS		OQS	
	Count	Percentage	Count	Percentage
12	592	30.98	478	41.24
13-24	434	22.71	288	24.85
25-36	276	14.44	93	8.02
37-48	119	6.23	75	6.47
49-60	137	7.17	54	4.66
61-120	253	13.34	118	10.18
121-180	45	2.36	28	2.41
181-240	33	1.72	24	1.74
241-360	10	0.52	3	0.26
Over 360	10	0.52	2	0.17
Total	1911	100.00	1159	100.00

PM3006517489

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

K. Respondent's Employment Status

Table I-20 Employment Status

Status	TS		OQS	
	Count	Percentage	Count	Percentage
Owner/director/self-employed	96	4.84	8	0.69
Employee (monthly paid)	1854	93.49	1144	98.96
Employee (daily/hourly paid)	9	0.45	4	0.35
Don't know/Refuse to answer	24	1.21	0	0.00
Total	1983	100.00	1156	100.00

Table I-21 Job Satisfaction

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	1481	74.68	427	38.19
No	182	9.18	167	14.94
No comment	272	13.72	524	46.87
Refuse to answer	48	2.42	0	0.00
Total	1983	100.00	1118	100.00

Table I-22 Second Job

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	136	6.86	22	1.96
No	1771	89.31	1066	94.76
No comment	31	1.56	37	3.29
Don't know / refuse	45	2.27	0	0.00
Total	1983	100.00	1125	100.00

L. Medical History

Table I-23 Asthma

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes but not in office	43	2.17	44	3.88
Yes and in office	28	1.41	5	0.44
No	1885	95.20	1084	95.68
Don't know / refuse	24	1.21	0	0.00
Total	1980	100.00	1133	100.00

Table I-24 Hay fever / pollen allergy

PM3006517490

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes but not in office	317	16.02	39	3.45
Yes and in office	153	7.73	7	0.62
No	1496	75.59	1085	95.93
Don't know / refuse	13	0.66	0	0.00
Total	1979	100.00	1131	100.00

Table I-25 Bronchitis

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes but not in office	93	4.70	98	8.77
Yes and in office	44	2.22	66	5.91
No	1806	91.30	952	85.23
Don't know / refuse	35	1.77	1	0.09
Total	1978	100.00	1117	100.00

Table I-26 Mould allergy

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes but not in office	56	2.83	36	3.22
Yes and in office	28	1.42	33	2.96
No	1781	90.09	1047	93.82
Don't know / refuse	112	5.66	0	0.00
Total	1977	100.00	1116	100.00

M. Overtime Working Condition

Table I-27 Over-time Work

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	948	47.93	598	51.73
No	915	46.26	558	48.27
Don't know / refuse	115	5.81	0	0.00
Total	1978	100.00	1156	100.00

PM3006517491
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table I-28 No. of Hours of Overtime Work per Week

No. of Hours	TS		OQS	
	Count	Percentage	Count	Percentage
1	37	4.90	660	56.95
2	83	10.99	100	8.63
3	115	15.23	68	5.87
4	70	9.27	60	5.18
5	124	16.42	81	6.99
6-10	226	29.93	155	13.37
11-15	62	8.22	17	1.47
16-20	20	2.65	12	1.03
21-40	10	1.32	5	0.45
> 40	8	1.06	1	0.09
Total	755	100.00	1159	100.00

Table I-29 Ventilation for Overtime Work

Ventilation Type	TS		OQS	
	Count	Percentage	Count	Percentage
Central AC	543	57.34	702	75.89
Window AC	140	14.78	8	0.87
Window	19	2.01	16	1.73
Mechanical Fan	8	0.84	12	1.30
Split AC Unit	97	10.24	19	2.05
None	95	10.03	168	18.16
Don't know/refuse	45	4.75	0	0.00
Total	947	100.00	925	100.00

N. Identification of Offices

Table I-30 Geographical Distribution of Respondent's Offices

Location	TS		OQS	
	Count	Percentage	Count	Percentage
Island West	48	2.43	2	0.17
Sheung Wan	74	3.75	64	5.54
Central	264	13.39	279	24.13
Wanchai	195	9.89	145	12.55
Causeway Bay	76	3.85	4	0.35
North Point / Quarry Bay	99	5.02	155	13.41
Other part of HK Island	67	3.40	1	0.09
Tsim Sha Tsui	282	14.30	189	16.35
Cheung Sha Wan	72	3.65	25	2.16
Kwun Tong	125	6.34	29	2.51
Other part of Kowloon	232	11.76	119	10.29
Tsuen Wan	114	5.78	39	3.37
Shatin	90	4.56	91	7.87
Other part of N.T.	203	10.29	14	1.21
Refuse to answer	31	1.57	0	0.00
Total	1972	100.00	1156	100.00

PM3006517492
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table I-31 Level (Floor) of Respondent's Offices

Floor	TS		OQS	
	Count	Percentage	Count	Percentage
0-5	668	42.82	276	23.98
6-10	304	23.33	258	22.41
11-15	218	13.98	335	29.11
16-20	130	8.33	84	7.30
21-30	122	7.82	119	10.34
31-40	43	2.76	57	4.95
41-50	12	0.77	10	0.87
51-60	2	0.19	10	0.87
> 60	1	0.06	2	0.18
Total	1560	100.00	1151	100.00

O. Office Profile

Table I-32 Type of Air-conditioning System

Ventilation Type	TS		OQS	
	Count	Percentage	Count	Percentage
Central AC	1317	66.92	1124	97.40
Window AC	276	14.02	10	0.87
Split AC Unit	278	14.13	19	1.64
None/Don't know	97	4.93	1	0.09
Total	1968	100.00	1154	100.00

Table I-33 Air-cleaning Equipment in Offices

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	186	9.46	44	3.81
No	1267	64.41	554	47.92
Don't know / refuse	514	26.13	558	48.27
Total	1967	100.00	1156	100.00

Table I-34 Improvement in Air Quality in Offices

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	96	50.53	38	12.67
No	20	10.53	79	26.33
Don't know / refuse	74	38.95	183	61.00
Total	190	100.00	300	100.00

Table I-35 Workstation Space

PM3006517493
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Type	TS		OQS	
	Count	Percentage	Count	Percentage
Single person office	259	13.18	50	4.33
Shared private office	535	27.23	103	8.93
Open space with partitions	641	32.62	585	50.69
Open space without partitions	498	25.34	394	34.14
Other	10	0.51	22	1.91
Don't know / refuse	22	1.12	0	0.00
Total	1965	100.00	1154	100.00

Table I-36 Spaciousness of Workspace

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Crowed	289	14.74	494	42.77
Satisfactory	950	48.47	594	51.43
Spacious	693	35.36	67	5.80
Don't know/Refuse	28	1.43	0	0.00
Total	1960	100.00	1155	100.00

Table I-37 Cooking in Office

	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	721	36.82	509	44.11
No	1230	62.82	645	55.89
Refuse to answer	7	0.36	0	0.00
Total	1958	100.00	1154	100.00

Table I-38 Open Window

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	631	32.24	202	17.53
No	1315	67.19	950	82.47
Don't know/Refuse	11	0.56	0	0.00
Total	1957	100.00	1152	100.00

Table I-39 Able to Open Window as Wishes by the Respondent

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	438	69.30	111	22.61
No	185	29.27	380	77.39
Don't know / refuse	9	1.42	0	0.00
Total	632	100.00	1152	100.00

Table I-40 Dusty Diffusers in Office

PM3006517494
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Often	397	20.30	316	27.62
Occasionally	507	25.92	459	40.12
Never	638	32.62	369	32.26
Don't know / refuse	414	21.16	0	0.00
Total	1956	100.00	1144	100.00

Table I-41 Carpet at Workstation

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	**1265**	**64.74**	**1077**	**93.33**
No	**683**	**34.95**	**77**	**6.67**
Don't know / refuse	**6**	**0.31**	**0**	**0.00**
Total	**1954**	**100.00**	**1154**	**100.00**

P. Smoking Policy in Offices

Table I-42 Smoking Policy in Offices

Smoking Policy	TS		OQS	
	Count	Percentage	Count	Percentage
Permitted in Office	302	33.15	195	17.09
Not permitted in Workplace	344	37.76	615	53.90
Only in specific area	90	9.88	191	16.74
Only in corridors/toilets	52	5.71	140	12.27
Don't know / refuse	123	13.50	0	0.00
Total	911	100.00	1141	100.00

Table I-43 Enforcement of Smoking Policy in Office

Smoking Policy Enforcement	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	827	42.32	645	56.28
No	702	35.93	501	43.72
Don't know / refuse	425	21.75	0	0.00
Total	1954	100.00	1146	100.00

Table I-44 Smokers Sitting Nearby

	TS				OQS			
	Smokers sitting		Smokers smoking in		Smokers sitting		Smokers smoking in	
	Count	%	Count	%	Count	%	Count	%
Yes	478	24.48	325	67.85	371	32.04	179	20.57
No	1456	74.55	144	30.06	618	53.37	691	79.43
Don't know /	19	0.97	10	2.09	169	14.59	0	0.00
Total	1953	100.00	479	100.00	1158	100.00	870	100.00

Table I-45 No. of Smokers Sitting Nearby

PM3006517495
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

No. of Smokers Sitting Nearby	TS		OQS	
	Count	Percentage	Count	Percentage
0	10	2.39	783	67.56
1	131	31.34	128	11.04
2	106	25.36	132	11.39
3	64	15.31	62	5.35
4	33	7.89	23	1.98
5	30	7.18	16	1.38
6-10	34	8.14	11	0.94
> 10	10	2.39	4	0.35
Total	418	100.00	1159	100.00

Q. Changes within 3m of the Respondent's Workstation over the past 3 Months

Table 1-46 Changes over the past 3 months

Response	TS				OQS			
	New Carpet within 3m		Walls Painted within 3m		New Carpet within 3m		Walls Painted within 3m	
	Count	%	Count	%	Count	%	Count	%
Yes	84	4.30	140	7.17	52	4.51	53	4.58
No	1836	94.01	1782	91.29	979	84.91	981	84.79
Don't know / refuse	33	1.69	30	1.53	122	10.58	123	10.63
Total	1953	100.00	1952	100.00	1153	100.00	1157	100.00

PM3006517496

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table I-47 Changes Over the Past 3 Months

Response	TS						OQS					
	New Furniture within 3m		New Partitions within 3m		Water Damage within 3m		New Furniture within 3m		New Partitions within 3m		Water Damage within 3m	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Yes	227	11.64	95	4.87	205	10.51	101	9.01	71	6.15	128	11.07
No	1699	87.08	1825	93.54	1690	86.67	921	79.81	948	82.08	846	73.18
Don't know / refuse	25	1.28	31	1.59	55	2.82	129	11.18	136	11.77	182	15.74
Total	1951	100.00	1951	100.00	1950	100.00	1154	100.00	1155	100.00	1156	100.00

R. Location of Particular Office Equipment from the Respondent's Workstation

Table I-48 Location of Particular Office Equipment from the Respondent's Workstation

Location of Equipment	TS						OQS					
	Photocopier		Laser Printer		Fax Machine		Photocopier		Laser Printer		Fax Machine	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Within 3m	437	22.42	544	27.93	584	29.98	320	27.83	528	48.75	331	29.01
More than 3m	916	47.00	566	29.06	850	43.63	530	46.08	371	34.26	482	42.24
In a different room	516	26.48	283	14.53	419	21.51	300	26.09	184	16.99	328	28.75
Don't know / refuse	80	4.10	555	28.49	95	4.88	0	0.00	0	0.00	0	0.00
Total	1949	100.00	1948	100.00	1948	100.00	1150	100.00	1083	100.00	1141	100.00

PM3006517497

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

S. Usage of Particular Stationery at Work

Table I-49 Usage of Particular Stationery Work

Frequency of Use	IS				OQS			
	Correction Fluid		Marker Pen		Correction Fluid		Marker Pen	
	Count	%	Count	%	Count	%	Count	%
> Once/day	1109	56.93	471	24.18	668	57.79	160	13.90
< Once/day	409	21.00	388	19.92	194	16.78	271	23.54
Rarely / Never	408	20.94	1077	55.29	294	25.43	720	62.55
Don't know / refuse	22	1.13	12	0.62	0	0.00	0	0.00
Total	1948	100.00	1948	100.00	1156	100.00	1151	100.00

Table I-50 Usage of Particular Stationery at Work

Frequency of Use	IS				OQS			
	Solvent Glue		Carbonless Paper		Solvent Glue		Carbonless Paper	
	Count	%	Count	%	Count	%	Count	%
> Once/day	105	5.39	278	14.27	26	2.27	127	11.05
< Once/day	154	7.91	230	11.81	97	8.46	138	12.01
Rarely / Never	1673	85.88	1429	73.36	1024	89.28	884	76.94
Don't know / refuse	16	0.82	11	0.56	0	0.00	0	0.00
Total	1948	100.00	1948	100.00	1147	100.00	1149	100.00

PM3006517498

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

T. Sick Building Syndrome Symptoms at Work

*Table I-51 Sick Building Syndrome Symptoms at Work (**Results from Telephone Survey**)*

Symptom	Mean	SD	No (%)	Yes (%)					Total no. of responses	Get Better (%)	Same (%)	Got Worse (%)	Hard to say (%)	No. (%)	Total no. of responses
				once /mth	twice /mth	< once /wk	< twice /wk	> twice /wk							
Eye Discomfort	1.68	5.11	76.00	2.43	6.06	6.51	3.96	5.04	1761	76.00	64.71	30.82	2.12	2.35	425
Runny Nose	0.31	2.24	92.45	2.67	2.28	1.67	0.22	0.72	1810	92.45	50.00	39.86	0.72	9.42	138
Sore/Dry Throat	1.46	4.28	74.27	3.55	6.07	7.96	4.01	4.13	1745	74.27	42.09	54.34	1.11	2.45	449
Cough	1.16	3.73	81.30	1.59	3.98	5.11	4.50	3.52	1759	81.30	42.30	54.68	0.91	2.11	331
Breathing Difficulty	0.27	2.05	95.85	0.70	0.97	0.97	0.38	0.81	1856	95.85	61.04	36.36	1.30	1.30	77
Sputum/ Phlegm	0.91	3.80	88.40	1.35	2.30	2.02	2.86	3.08	1784	88.40	31.25	63.46	0.96	4.33	208
Headache	1.16	3.59	75.83	4.20	6.67	6.73	3.68	2.88	1738	75.83	56.29	38.72	0.95	4.04	421
Dizziness	0.43	2.27	91.35	1.20	2.56	2.33	1.47	1.09	1839	91.35	62.26	35.85	1.26	0.63	159
Dry/ Itchy Skin	0.98	4.25	87.90	1.36	2.67	3.13	1.87	3.07	1760	87.90	43.93	50.47	0.93	4.67	214
Tiredness	2.94	7.03	71.87	2.13	3.01	5.01	6.74	10.64	1692	71.87	70.50	26.78	1.26	1.47	478
Hard to Remember	0.68	3.08	87.96	1.41	3.66	3.38	1.63	1.97	1777	87.96	71.03	25.23	0.47	3.27	214

PM3006517499

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

*Table I-52 Sick Building Syndrome Symptoms at Work (**Results from On-Site Questionnaire Survey**)*

Symptom	Mean	SD	No symptom (%)	Yes (frequency expressed in no. of days per week) (%)							Total no. of responses	Get better away from work	Same away from work	Got worse away from work	Hard to say	Total no. of responses
				1	2	3	4	5	6	7						
Eye Discomfort	1.49	1.81	45.64	14.32	15.19	10.53	5.54	7.59	1.64	1.55	1159	49.26	47.90	2.84	0.00	810
Runny Nose	1.29	1.89	55.74	12.94	9.23	8.54	3.02	5.95	1.73	2.85	1159	42.04	55.17	2.79	0.00	754
Blocked Nose	1.03	1.77	63.85	11.04	8.54	5.35	3.36	4.23	0.69	2.93	1159	37.34	59.74	2.93	0.00	683
Sinusitis	0.17	0.80	93.62	2.67	1.04	0.95	0.52	0.60	0.09	0.52	1159	15.56	83.52	0.93	0.00	540
Sore/ Dry Throat	1.29	1.77	51.68	14.93	11.91	9.15	3.62	5.52	1.38	1.81	1159	42.71	54.95	2.34	0.00	768
Cough	0.93	1.54	61.86	14.06	9.75	6.38	2.93	2.59	1.21	1.21	1159	33.71	63.61	2.68	0.00	709
Wheeze	0.37	1.09	85.33	5.26	3.71	2.50	0.95	1.21	0.52	0.52	1159	17.19	81.58	1.23	0.00	570
Breathing Difficulty	0.38	1.06	83.87	6.47	4.14	2.50	0.69	1.64	0.35	0.35	1159	25.56	72.90	1.54	0.00	583
Sneeze	1.77	1.94	37.62	16.91	16.05	10.96	5.78	7.42	2.16	3.11	1159	46.87	49.88	3.25	0.00	830
Sputum/ Phlegm	0.90	1.62	66.78	10.53	7.85	6.64	1.98	3.36	1.21	1.64	1159	24.52	72.67	2.81	0.00	677
Vomit	0.18	0.72	91.20	4.23	2.33	1.12	0.43	0.35	0.09	0.26	1159	17.95	80.79	1.26	0.00	557
Headache	1.18	1.57	49.87	17.86	14.15	9.58	3.45	2.67	1.12	1.29	1159	45.10	51.80	2.96	0.13	776
Dizziness	0.58	1.20	73.34	11.56	6.99	3.62	2.24	1.55	0.26	0.43	1159	35.29	62.71	2.00	0.00	649
Dry/ Itchy Skin	1.01	1.72	65.06	9.75	8.02	6.82	2.50	4.66	1.29	1.90	1159	34.75	62.46	2.79	0.00	682
Skin Allergy	0.32	1.07	88.18	4.31	2.76	1.47	0.95	1.12	0.43	0.78	1159	17.94	80.64	1.42	0.00	563
Tiredness	2.01	2.13	38.65	11.73	13.46	12.17	5.52	11.30	3.28	3.88	1159	55.01	40.69	4.30	0.00	838
Hard to Remember	1.14	1.67	55.31	15.62	10.44	7.77	3.97	4.31	1.29	1.29	1159	46.02	51.82	2.16	0.00	741
Stomach Pain	0.57	1.21	74.03	10.44	7.16	4.57	1.55	1.29	0.43	0.52	1159	26.42	71.43	2.15	0.00	651
Muscle Pain	0.83	1.59	70.84	7.77	6.64	6.21	3.19	2.93	0.95	1.47	1159	28.28	69.55	2.16	0.00	647
Diarrhoea	0.28	0.84	84.99	8.54	3.28	1.73	0.60	0.35	0.26	0.26	1159	19.18	79.45	1.37	0.00	584
Fever	0.13	0.56	91.98	5.26	1.90	0.17	0.35	0.00	0.26	0.09	1159	16.33	83.12	0.54	0.00	551

PM3006517500

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

U. Use of Eyedrops

Table I-53 Use of Eyedrops at Work

Use of Eyedrops	TS		OQS	
	Count	Percentage	Count	Percentage
Yes	325	16.69	978	84.38
No	1595	81.92	181	15.62
Don't know / refuse	27	1.38	0	0.00
Total	1947	100.00	1146	100.00

Table I-54 Use of Eyedrops per Day

Frequency of Use per day	TS		OQS	
	Count	Percentage	Count	Percentage
0	82	30.37	977	84.30
1	93	34.44	110	9.49
2	65	24.07	42	3.62
3	21	7.78	18	1.55
4	7	2.59	5	0.43
¤ 5	2	0.74	7	0.61
Total	270	100.00	1159	100.00

V. Sickness over the Past Month

Table I-55 No. of Cold/Flu Over the Past Month

No. of Cold/Flu	TS		OQS	
	Count	Percentage	Count	Percentage
0	1118	59.66	465	40.16
1-5	677	39.33	651	56.21
6-10	11	0.48	22	1.90
11-15	4	0.22	8	0.69
¤ 15	4	0.22	12	1.04
Total	1874	100.00	1158	100.00

Table I-56 No. of days Felt Unwell Over the Past Month

No. of days	TS		OQS	
	Count	Percentage	Count	Percentage
0	42	5.70	467	40.43
1-5	484	65.68	511	44.25
6-10	144	19.54	134	11.60
11-15	41	5.57	27	2.34
16-20	10	1.36	12	0.18
21-25	4	0.54	4	0.35
> 25	12	1.64	0	0.00
Total	737	100.00	1155	100.00

PM3006517501

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table I-57 Sick Leave Over the Past Month

No. of days	TS		OQS	
	Count	Percentage	Count	Percentage
0	1521	79.55	800	69.03
1	262	13.70	255	22.00
2	95	4.97	84	7.25
3	16	0.84	8	0.69
4	9	0.47	2	0.17
≥ 5	9	0.47	10	0.86
Total	1912	100.00	1159	100.00

W. Information on Public Places and MTR

Table I-58 Usual Day of the Week To Go To Shopping Malls

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Weekdays	89	4.59	41	3.54
Weekends	830	42.76	449	38.81
Depends	812	41.83	667	57.65
Don't know / refuse	210	10.82	0	0.00
Total	1941	100.00	1157	100.00

Table I-59 Respondent's Perception on Indoor Air Quality (IAQ) of Public Places

Respondent's Perception on IAQ	TS						OQS					
	Shopping Mall		Restaurants		Cinemas		Shopping Mall		Restaurants		Cinemas	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Satisfied	849	43.81	386	19.92	1177	60.73	109	9.45	14	1.21	86	7.50
OK	509	26.26	504	26.01	194	10.01	791	68.54	715	61.91	704	61.37
Dissatisfied	356	18.37	855	44.11	550	28.38	129	11.18	344	29.78	111	9.68
No Opinion	224	11.56	193	9.95	17	0.88	125	10.83	82	7.10	246	21.45
Total	1938	100.00	1938	100.00	1938	100.00	1154	100.00	1155	100.00	1147	100.00

PM3006517502

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Table I-60 Respondent's Experience on Feeling Dizzy While Travelling with MTR

Location of Dizziness Experienced	TS		OQS	
	Count	Percentage	Count	Percentage
At Platform	43	2.22	98	8.52
In Train Compartment	352	18.17	428	37.22
Never	1508	77.85	624	54.26
Don't know / refuse	34	1.75	0	0.00
Total	1937	100.00	1150	100.00

X. General Opinion on IAQ

(Statement 1) A health working environment would increase productivity.

Table I-61 Respondent's Opinion on Statement 1

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Strongly Agree	541	27.96	451	38.95
Agree	1320	68.22	637	55.01
No Opinion	30	1.55	61	5.27
Disagree	23	1.19	9	0.78
Don't know / refuse	21	1.08	0	0.00
Total	1935	100.00	1158	100.00

(Statement 2) It is the employer's responsibility to provide a good workplace environment.

Table I-62 Respondent's Opinion on Statement 2

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Strongly Agree	581	30.03	625	54.02
Agree	1299	67.13	495	42.78
No Opinion	25	1.29	34	2.94
Disagree	12	0.62	3	0.26
Don't know / refuse	18	0.93	0	0.00
Total	1935	100.00	1157	100.00

PM3006517503
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

(Statement 3) Employees should also make an effort to provide a satisfactory workplace environment.

Table I-63 Respondent's Opinion on Statement 3

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Strongly Agree	377	19.48	379	32.81
Agree	1438	74.32	681	58.96
No Opinion	47	2.43	87	7.53
Disagree	39	2.02	6	0.52
Strongly Disagree	1	0.05	2	0.17
Don't know / refuse	33	1.70	0	0.00
Total	1935	100.00	1155	100.00

(Statement 4) If we had workplace environmental problem, our employer would willingly and promptly respond to solve the problem.

Table I-64 Respondent's Opinion on Statement 4

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Strongly Agree	105	5.43	126	10.88
Agree	865	44.70	364	31.43
No Opinion	183	9.46	365	31.52
Disagree	554	28.63	265	22.88
Strongly Disagree	42	2.17	38	3.28
Don't know / refuse	186	9.61	0	0.00
Total	1935	100.00	1158	100.00

(Statement 5) Smoking should be prohibited by law in all offices and public places (indoors).

Table I-65 Respondent's Opinion on Statement 5

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Strongly Agree	552	28.53	690	60.00
Agree	1087	56.18	332	28.87
No Opinion	80	4.13	102	8.87
Disagree	161	8.32	19	1.65
Strongly Disagree	14	0.72	7	0.61
Don't know / refuse	41	2.12	0	0.00
Total	1935	100.00	1150	100.00

PM3006517504

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

(Statement 6) Government should be actively involved in establishing building codes - ventilation rates, design standards to improve indoor air quality.

Table I-66 Respondent's Opinion on Statement 6

Response	TS		OQS	
	Count	Percentage	Count	Percentage
Strongly Agree	389	20.10	626	54.29
Agree	1311	67.75	444	38.51
No Opinion	87	4.50	74	6.42
Disagree	74	3.82	5	0.43
Strongly Disagree	7	0.36	4	0.35
Don't know / refuse	67	3.46	0	0.00
Total	1935	100.00	1153	100.00

Table I-67 Respondent's Opinion on Government Department Responsible for IAQ Problem

Government Department	TS		OQS	
	Count	Percentage	Count	Percentage
Environmental Protection Department	1069	55.25	871	75.94
Architectural Services Department	48	2.48	71	6.19
Electrical and Mechanical Services Department	48	2.48	71	6.19
Department of Health	229	11.83	102	8.89
Labour Department	35	1.81	27	2.35
Others	100	5.17	5	0.44
Don't know / refuse	406	20.99	0	0.00
Total	1935	100.00	1153	100.00

PM3006517505

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Section 2 : Frequency Distribution Shown by Histogram & Charts

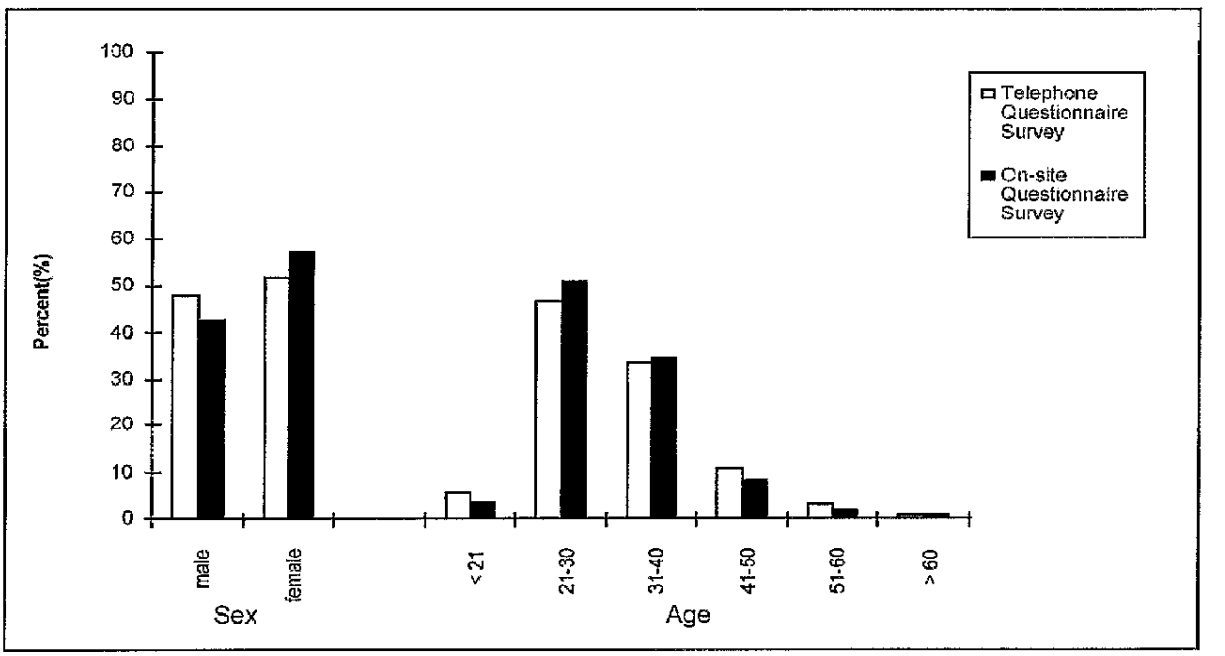


Figure 1-1 Profile of Population: Sex and Age

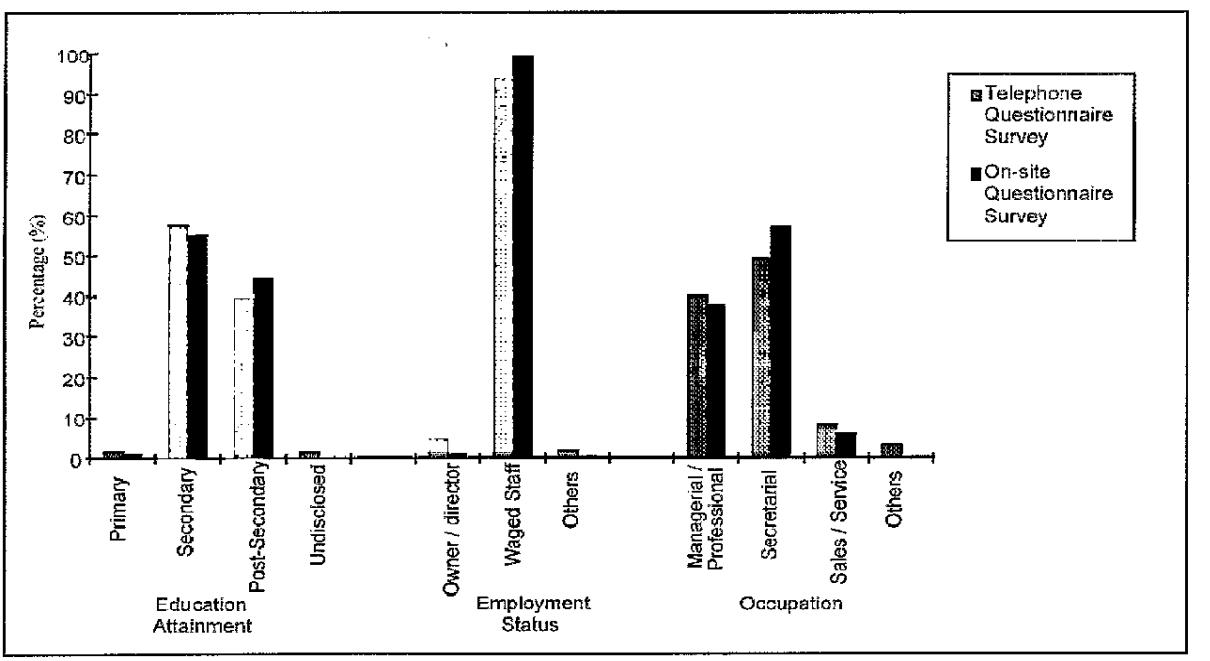


Figure 1-2 Profile of Population: Education, Employment Status and Occupation

PM3006517506

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

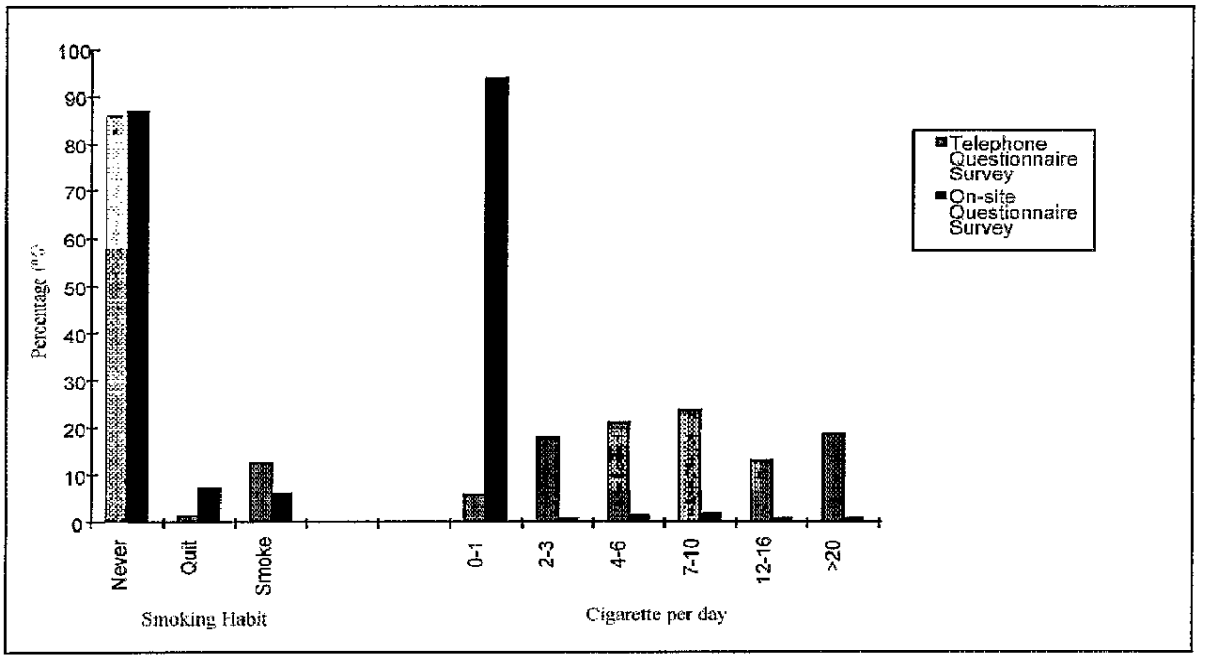


Figure I-3 Profile of Population: Smoking (Smoking Habit & Cigarette Per Day)

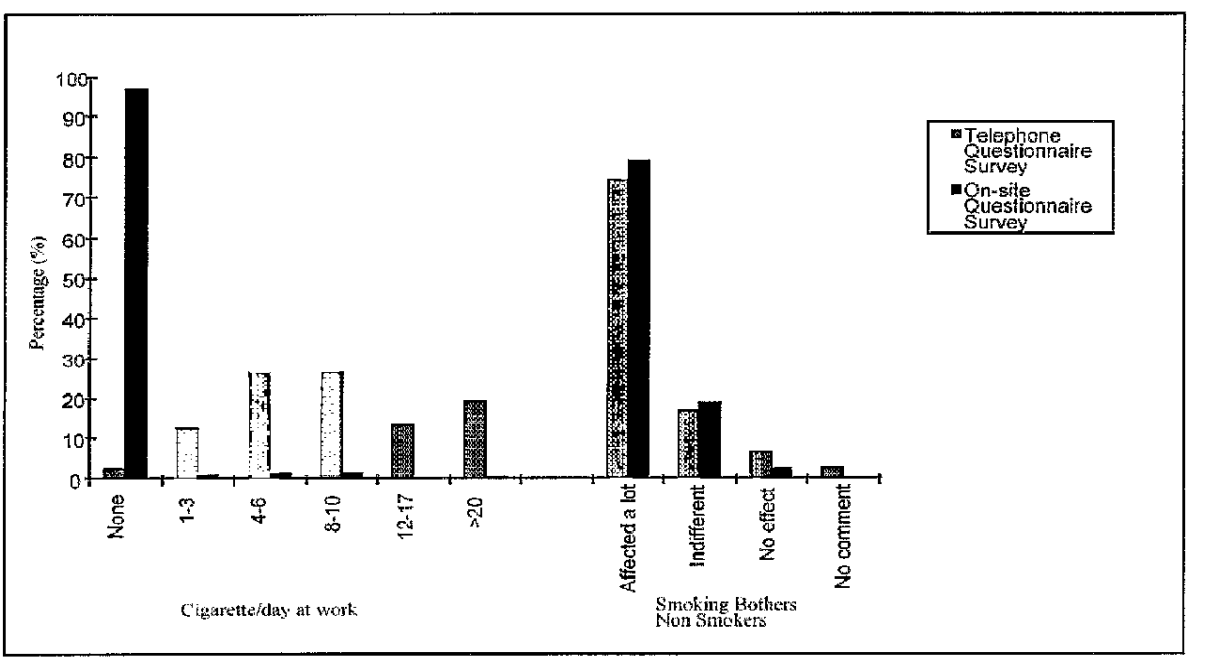


Figure I-4 Profile of Population: Smoking (Cigarette Per Day at Work & Smoking Bothers)

PM3006517507

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

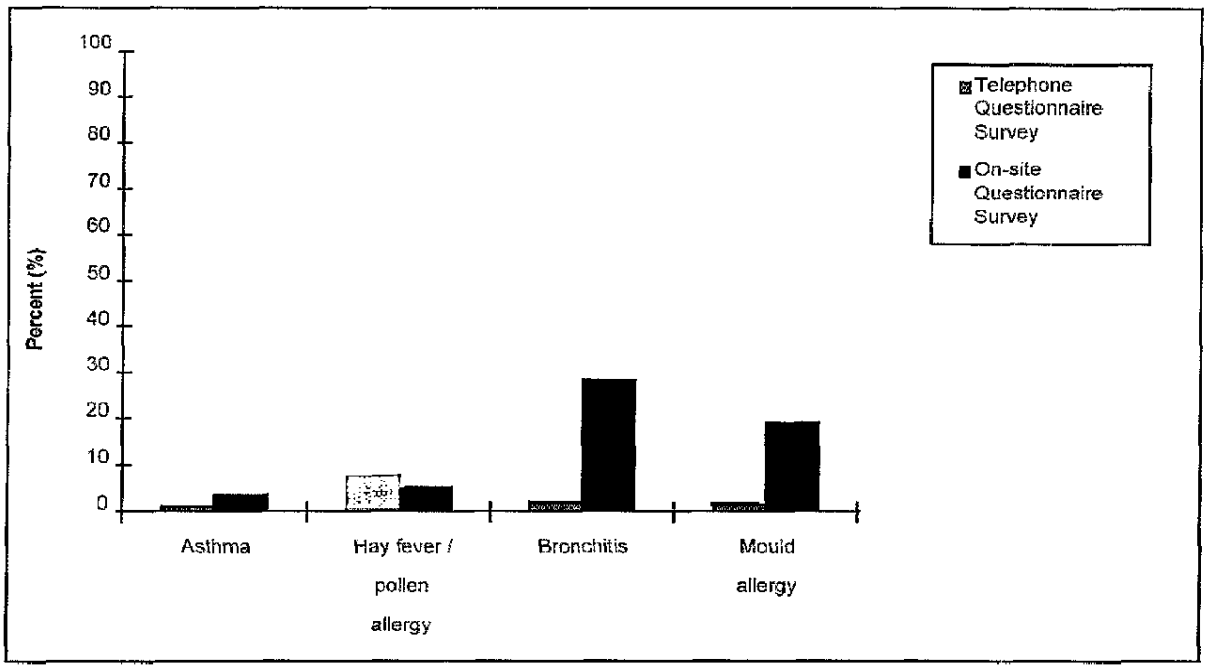


Figure I-5 Profile of Population: Medical Condition Present & Started in Present Office

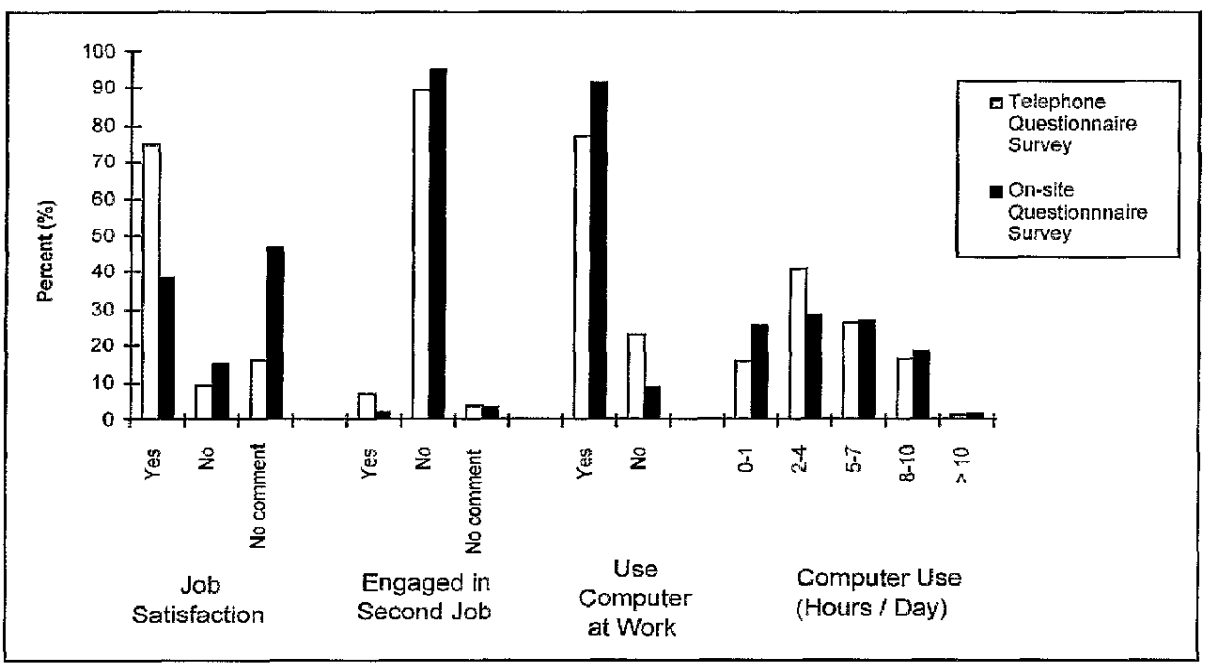


Figure I-6 Profile of Population: Work Pattern and Satisfaction

PM3006517508
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

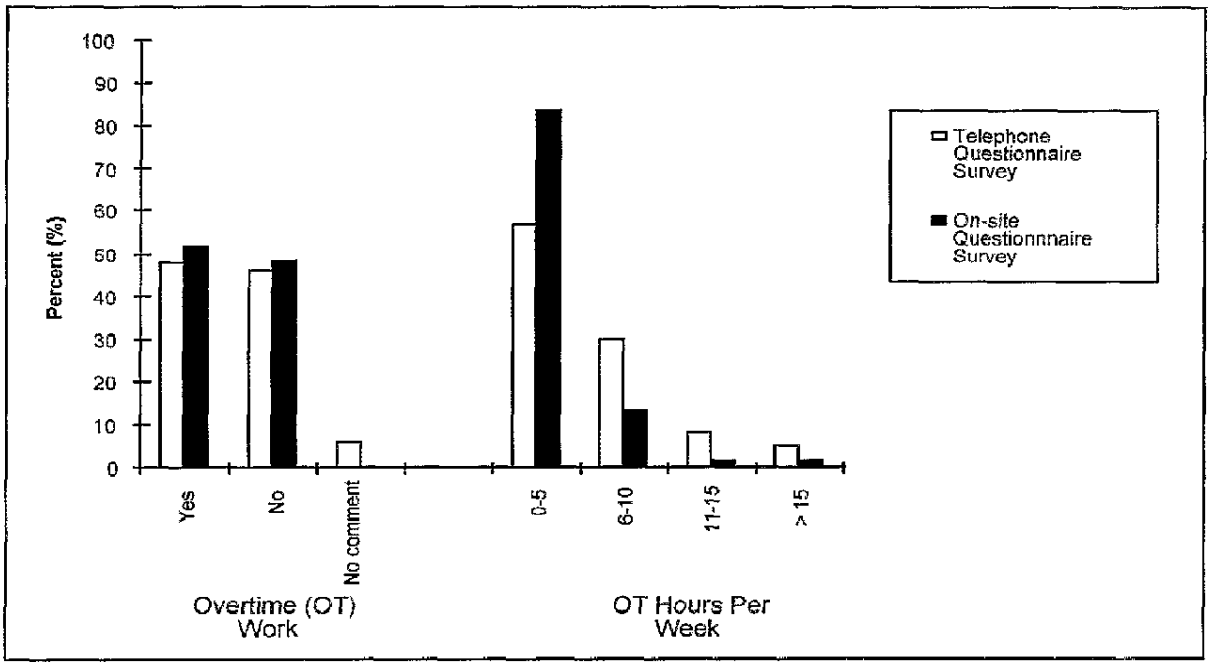
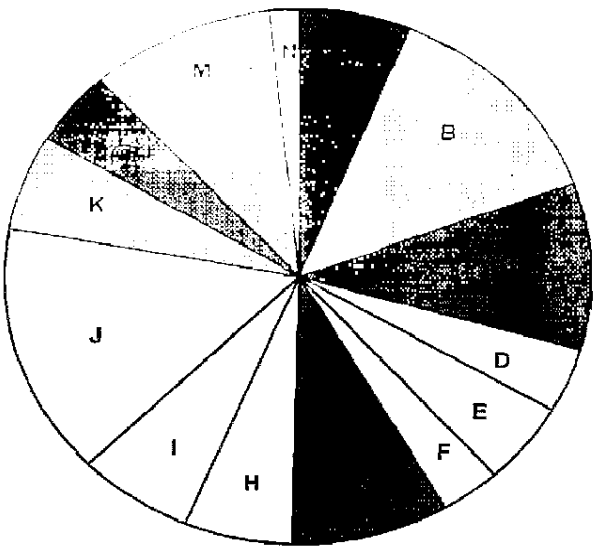


Figure I-7 Profile of Population: Overtime

PM3006517509

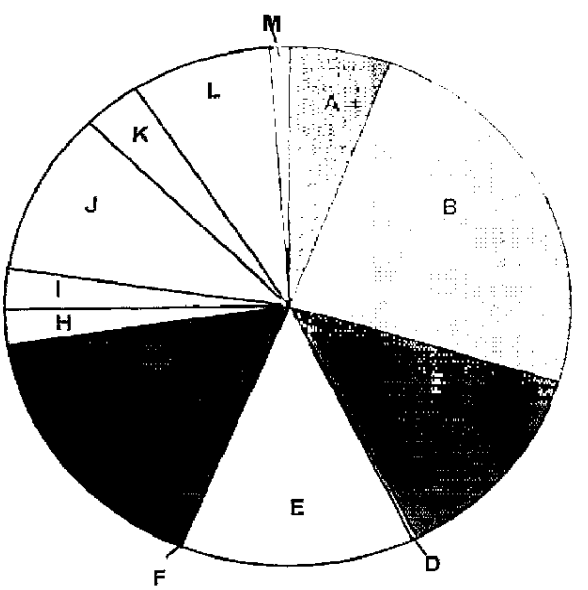
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Telephone Questionnaire Survey



Legend :	Percent (%)
A. Island West (inc. Sheung Wan)	6.19
B. Central	13.39
C. Wan Chai	9.89
D. Causeway Bay	3.85
E. North Point / Quarry Bay	5.02
F. Other areas of Hong Kong Island	3.40
G. Tsim Sha Tsui	8.67
H. Yan Ma Tei / Mongkok	5.63
I. Kwun Tong	6.34
J. Other areas of Kowloon Peninsula	15.41
K. Tsuen Wan	5.78
L. Shatin	4.56
M. Other areas of the New Territories	10.29
N. Unknown	1.58

On-site Questionnaire Survey



Legend :	Percent (%)
A. Island West (inc. Sheung Wan)	5.71
B. Central	24.13
C. Wan Chai	12.55
D. Causeway Bay	0.35
E. North Point / Quarry Bay	13.41
F. Other areas of Hong Kong Island	0.09
G. Tsim Sha Tsui	16.35
H. Cheung Sha Wan	2.16
I. Kwun Tong	2.51
J. Other areas of Kowloon Peninsula	10.29
K. Tsuen Wan	3.37
L. Shatin	7.87
M. Other areas of the New Territories	1.21

Figure 1-8 Working Condition: Distribution of Office Location

PM3006517510
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

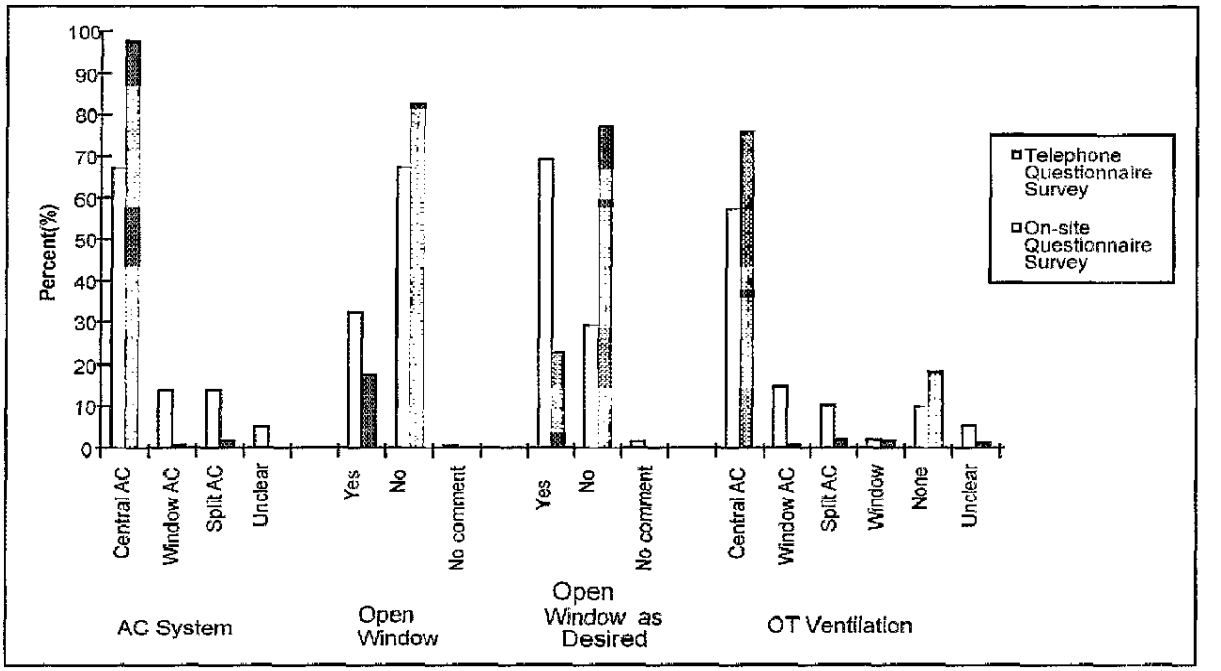


Figure I-9 Working Condition: Ventilation

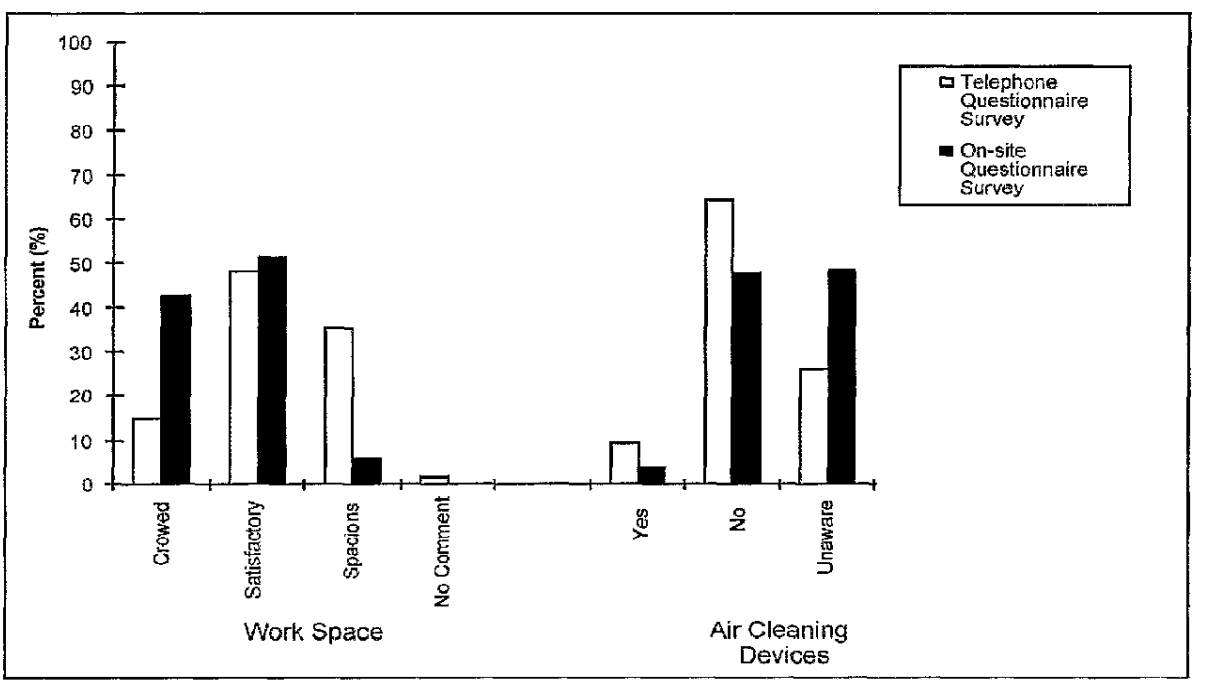


Figure I-10 Working Condition: Space and Workplace Condition

PM3006517511
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

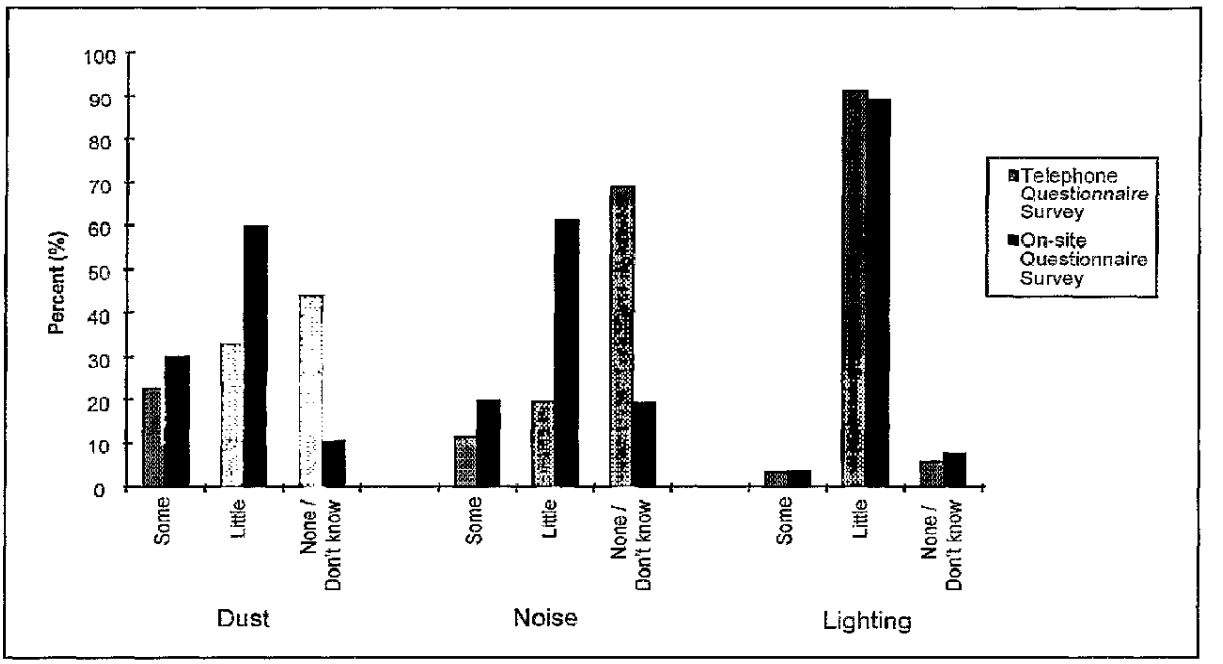


Figure I-11 Working Condition: Dust / Noise / Lighting Problem at Workplace

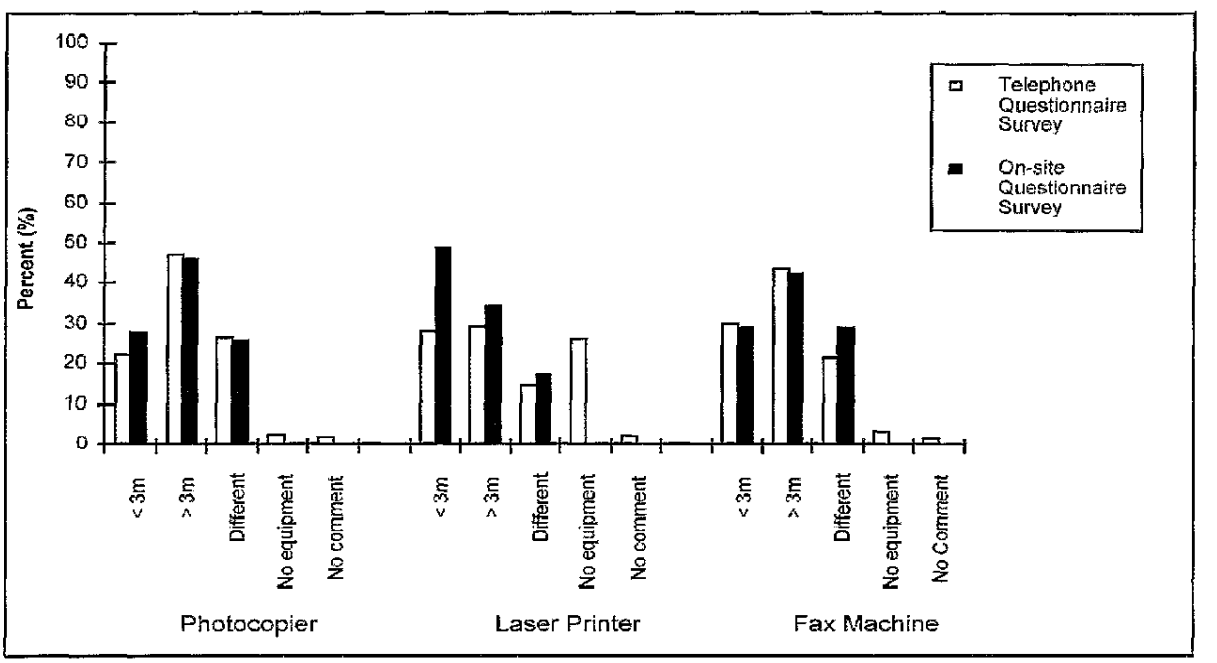


Figure I-12 Working Condition: Distance of Office Equipment From Workstation

PM3006517512
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

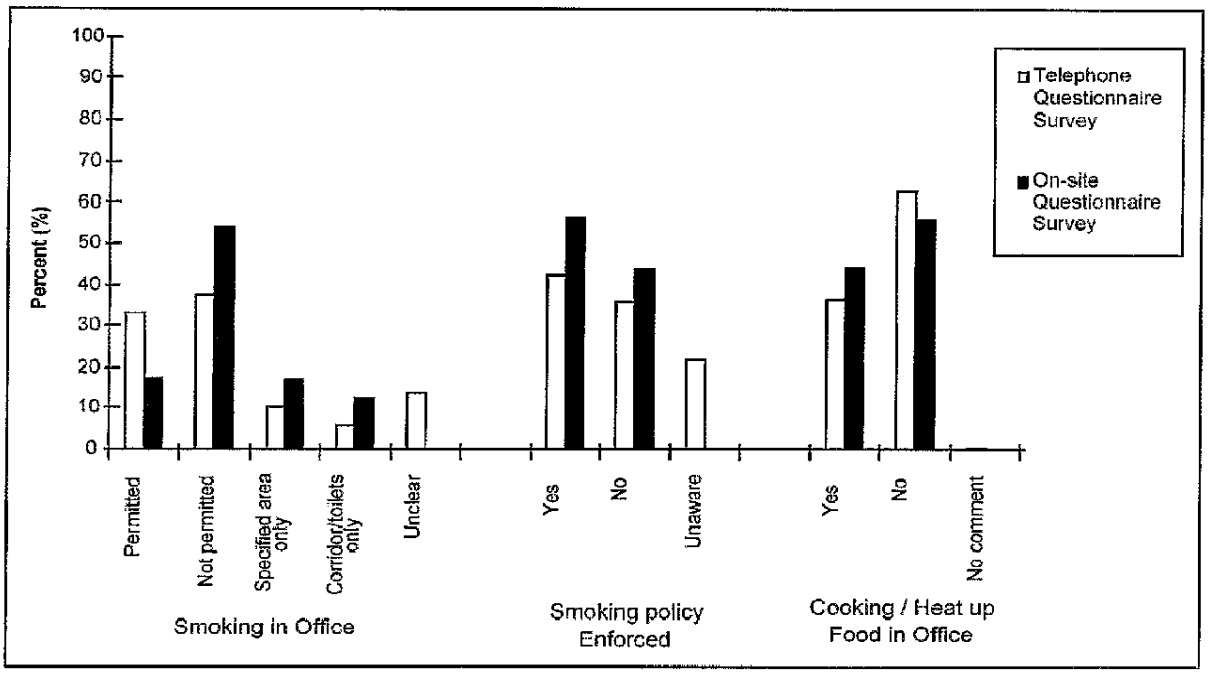


Figure I-13 Working Condition: Smoking And Eating Policy

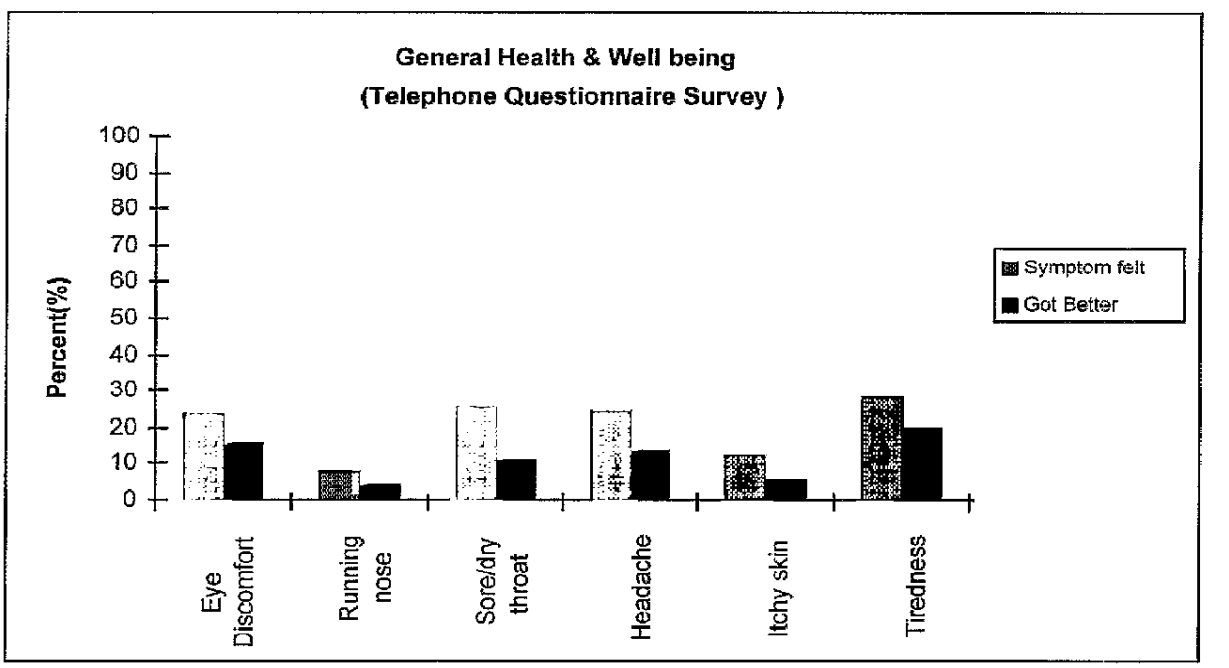


Figure I-14 General Health & Well Being (Telephone Questionnaire Survey)

PM3006517513
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

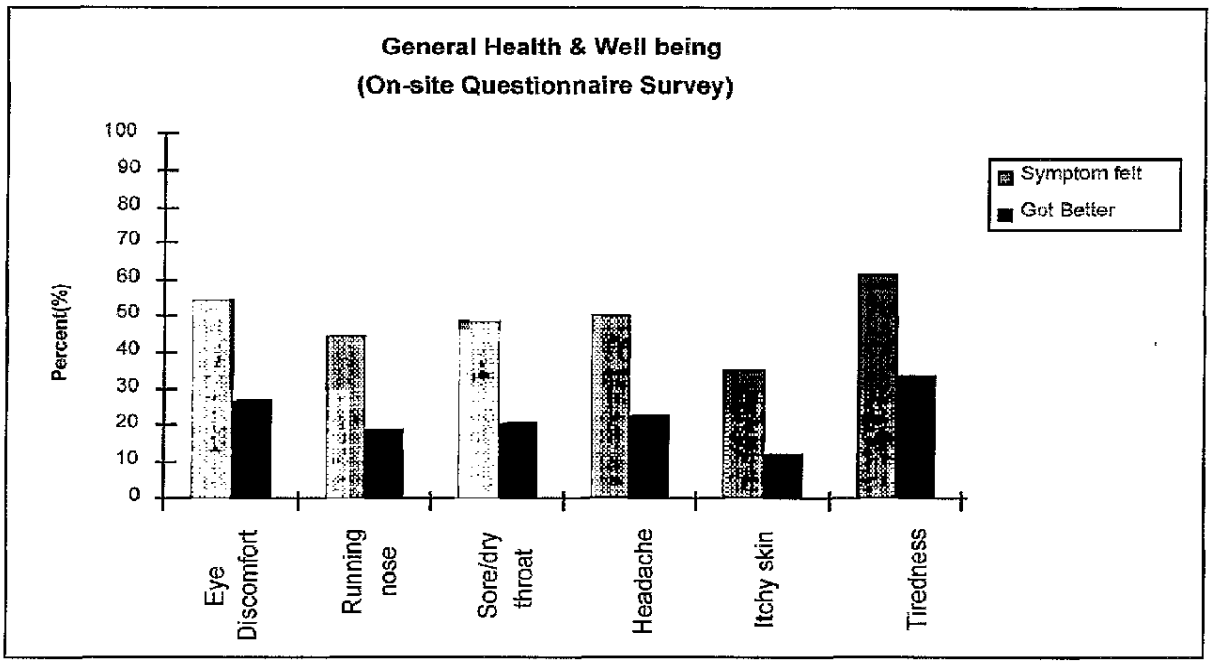


Figure I-15 General Health & Well Being (On-site Questionnaire Survey)

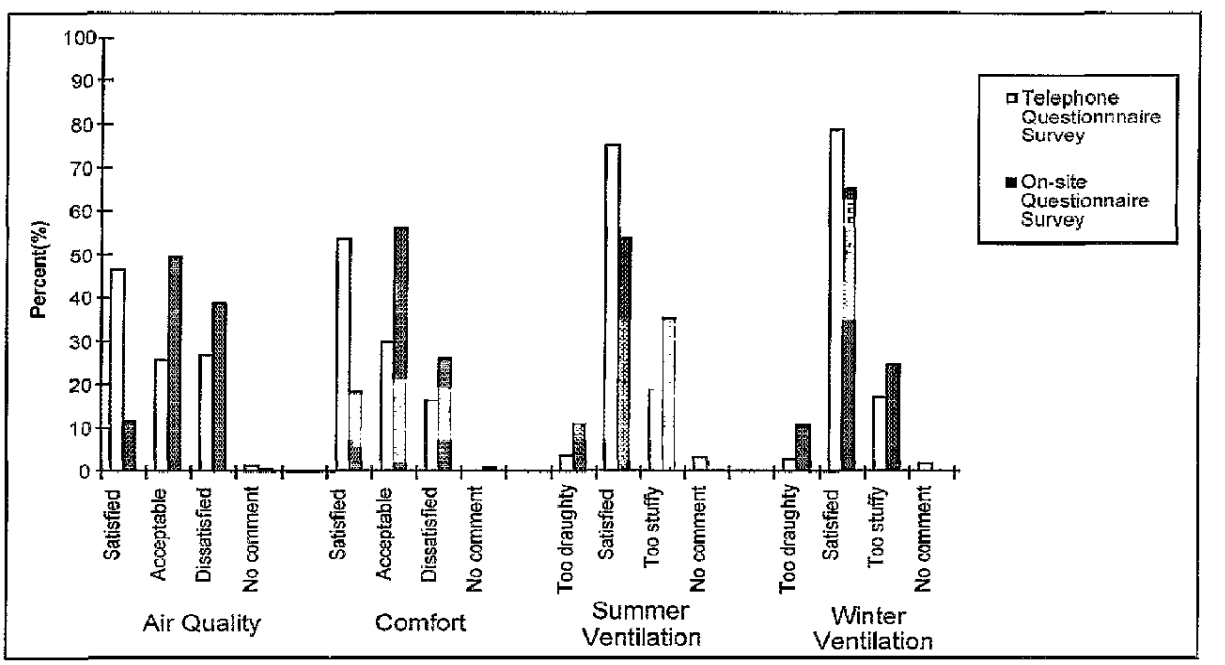


Figure I-16 Perceptions of Workplace Condition

PM3006517514
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

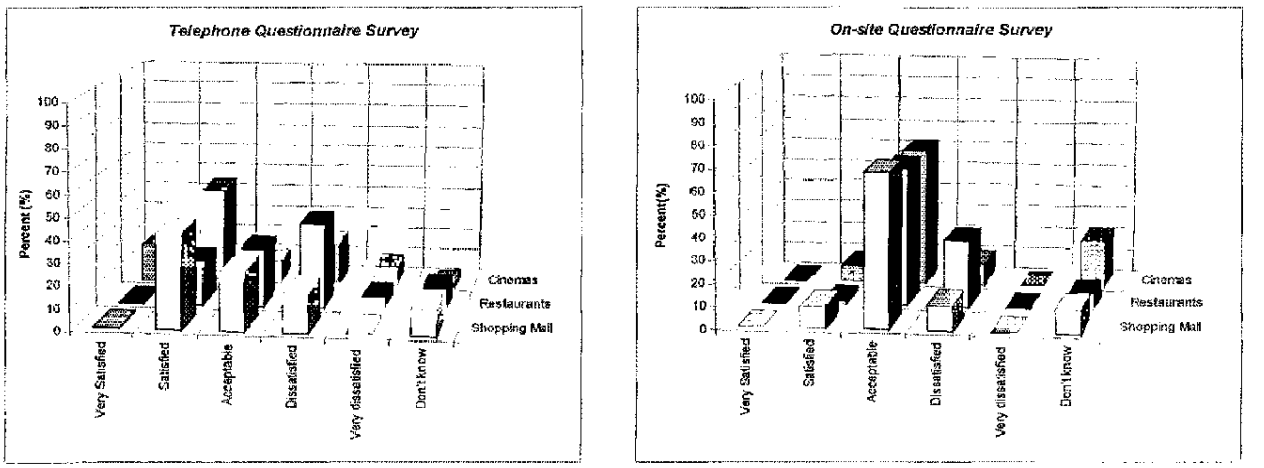


Figure I-17 Perception of Air Quality in Public Places

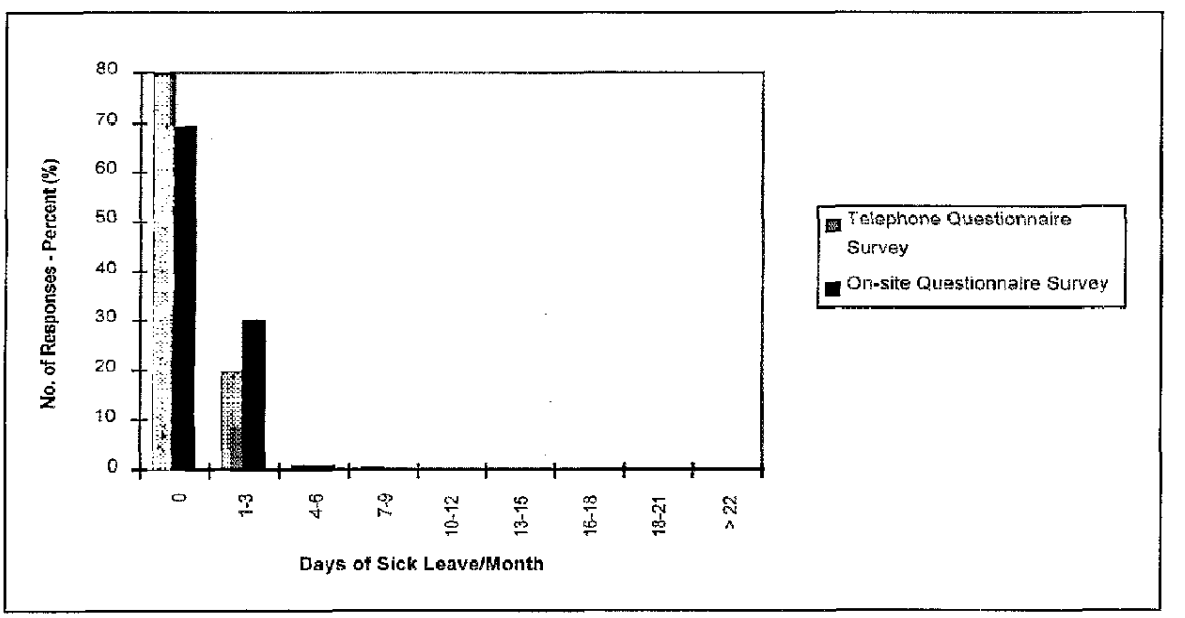


Figure I-18 Days of Sick Leave

PM3006517515
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

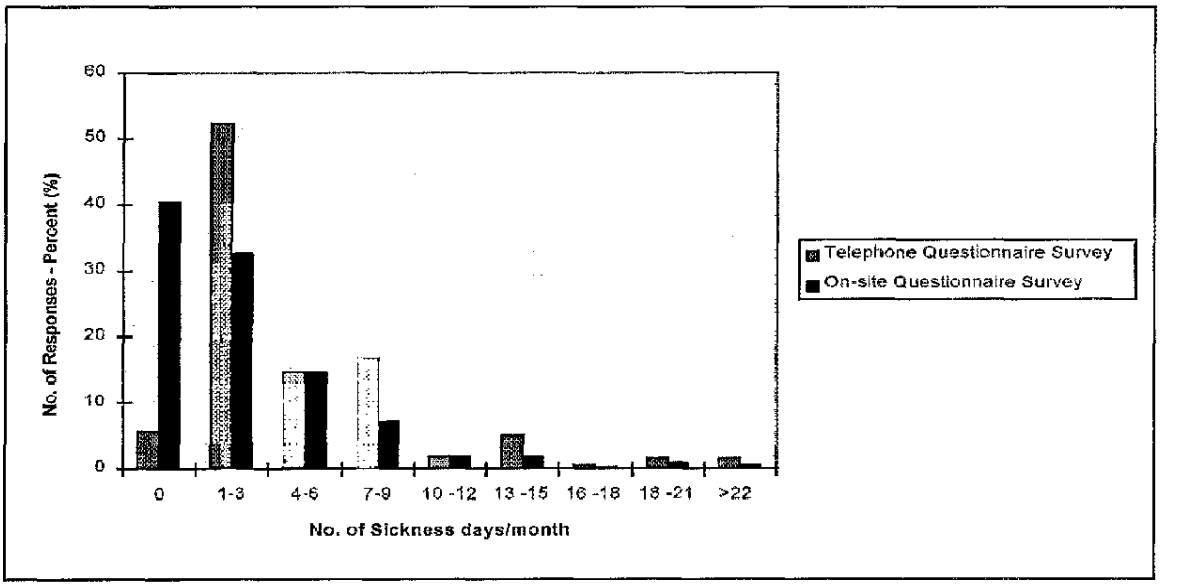


Figure I-19 Days of Individual Suffering Cold/Flu

PM3006517516

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX VI

Protocol and Results of On-site Survey - Offices Premises

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

VI-1 Office Premises Characteristics

Office	Date	Class	District	Bldg Age	MVAC	No. of Occupants	Average Occupancy Density (m^2/hd)	Fresh Air Intake	Smoking	Study Area(s) Affected by Renovation
Ia	18/03/96	A	North Point	5	VAV	26	12.84	24/F Roof	Not Permitted	A4 for Ia and Ib
IIa	25/03/96	B	Tsim Sha Tsui	31	FCU	14	14.69	15/F Roof	Not Permitted	
IIIa	03/04/96	A	Wan Chai	5	VAV	12	16.35	44/F Fire Refuge Floor	Permitted	At the neighboring unit for IIIa and IIIb
IVa	12/04/96	A	Wan Chai	17	VAV	15	12.40	30/F Fire Refuge Floor	Not Permitted	A2 and B9 for IVc and IVd
IX	05/05/96	U	Shatin	3	VAV+FCU	18	11.41	15/F Roof	Restricted to Smoking Lounges	
V	19/04/96	U	Lai Chi Kok	7	FCU	16	7.75	16/F Roof	Permitted but No Smoker	
VI	20/05/96	A	Lai Chi Kok	8	FCU	19	12.50	12/F Roof	Permitted	
VII	03/06/96	A	Quarry Bay	4	VAV	216	31.61	34/F Roof	Restricted to Toilet	
VIII	04/06/96	G	Ho Man Tin	5	VAV	147	2.83	11/F Roof	Not Permitted Except Visitors	
X	06/06/96	A	Central	11	VAV	186	7.37	20/F Podium	Restricted to Private Office	
XI	27/06/96	B	Central	35	FCU	34	3.75	Light Well In Middle Level	Permitted	
XII	28/06/96	A	Central	10	VAV	35	19.56	21/F Refuge Floor	Not Permitted	
XIII	03/07/96	A	Wan Chai	12	VAV	17	22.28	27/F Fire Refuge Floor	Restricted to Lift and Lobby	
XIV	05/07/96	A	North Point	13	VAV	68	7.28	18/F Fire Refuge Floor	Not Permitted	
XIX	16/07/96	A	Tsuen Wan	3	FCU	45	7.95	Street Level	Not Permitted	
XVa	09/07/96	B	Kwai Fong	14	FCU	12	10.91	Street Level	Not Permitted	
XVI	10/07/96	B	Central	28	FCU	28	6.35	24/F Roof	Not Permitted	
XVII	11/07/96	B	Central	13	CAV	126	8.97	1/F Podium	Permitted	
XVIII	12/07/96	A	Tsim Sha Tsui	16	FCU	42	6.25	12/F Roof	Restricted to Private Office	
XX	17/07/96	U	North Point	6	FCU	95	22.11	13/F Roof	Permitted	
XXI	18/07/96	A	Tsim Sha Tsui	29	FCU	40	11.29	18/F	Not Permitted	
XXII	19/07/96	B	Tsim Sha Tsui	7	FCU	29	11.29	Roof	Permitted	
XXIII	22/07/96	B	Wan Chai	4	VAV	83	9.30	39/F Roof	Not Permitted	B9
XXIV	23/07/96	B	Wan Chai	14	FCU	37	4.42	28/F Roof	Not Advised	
XXIX	14/08/96	A	Tsim Sha Tsui	6	FCU	154	20.97	3/F Podium	Permitted	
XXV	25/07/96	A	Kowloon Bay	4	FCU	30	3.69	24/F Roof	Not Permitted	
XXVI	26/07/96	B	Central	23	FCU	34	13.40	Street Level	Restricted to Smoking Lounges	
XXVII	30/07/96	A	Central	6	VAV	37	7.26	Street Level	Not Permitted	
XXVIII	07/08/96	A	Tsim Sha Tsui	16	FCU	23	20.36	15/F Roof	Permitted	
XXX	15/08/96	B	Central	17	VAV	92	7.91	4/F Podium	Permitted	
XXXI	20/08/96	A	Tsim Sha Tsui	13	VAV	27	20.00	18/F Roof	Not Permitted	
XXXII	21/08/96	B	Central	31	FCU	20	3.33	6/F	Permitted (No Smoker)	
XXXIII	23/08/96	A	Central	8	VAV	14	14.71	Roof	Permitted	At the neighboring unit
XXXIV	28/08/96	A	Central	21	FCU	6	27.01	24/F Roof	Not Permitted	
XXXIX	03/10/96	B	Wan Chai	21	FCU	31	80.00	4/F Outside of the windoow	Restricted to Staircase	
XXXV	29/08/96	A	Central	21	CAV	17	10.72	24/F Roof	Permitted	
XXXVI	13/09/96	C	Wan Chai	15	CAV	43	11.67	24/F Roof	Permitted	
XXXVII	19/09/96	G	Admiralty	27	FCU	67	14.74	8/F Air Riser	Restricted to Stairways	
XXXVIII	24/09/96	U	Shatin	3	VAV	47	29.23	10/F Roof	Not Permitted	
XXXX	25/10/96	A	Admiralty	9	VAV	33	3.79	21/F Roof	Restricted to Smoking Lounges	

PM3006517518

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

VI-2 Office Premises Involved in the Longitudinal Study

ID	Survey Date	Building Class	District	Building Age	Type of MVAC System
OFF-Ia	18/3/96 (Monday)	A	North Point	5	VAV - Reheat
OFF-Ib	22/3/96 (Friday)				
OFF-Ic	2/8/96 (Friday)				
OFF-Id	5/8/96 (Monday)				
OFF-IIa	25/3/96 (Monday)	B	Tsim Sha Tsui	31	FCU
OFF-IIb	29/3/96 (Friday)				
OFF-IIc	9/8/96 (Friday)				
OFF-IId	12/8/96 (Monday)				
OFF-IIIa	3/4/96 (Wednesday, before Easter holiday)	A	Wan Chai	5	VAV
OFF-IIIb	9/4/96 (Tuesday, after Easter holiday)				
OFF-IIIc	30/8/96 (Friday)				
OFF-IIId	2/9/96 (Monday)				
OFF-IVa	12/4/96 (Friday)	A	Wan Chai	17	VAV - Simple
OFF-IVb	15/4/96 (Monday)				
OFF-IVc	16/8/96 (Friday)				
OFF-IVd	19/8/96 (Monday)				
OFF-XVa	9/7/96 (Tuesday)	B	Kwai Fong	14	FCU
OFF-XVb	27/8/96 (Tuesday, after a public holiday)				
OFF-XVc	13/12/96 (Friday)				
OFF-XVd	16/12/96 (Monday)				

PM3006517519

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX VII

Protocol and Results of On-site Survey - Public Places

PM3006517520

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

VII-1 Summary of the 20 Surveyed Restaurants

Code	Date	Type	Dinner/Lunch	District	Naked Fire in the Dining Area
RES-I	29/09/96	Korean Barbecue	Dinner	Tsim Sha Tsui	Yes
RES-II	16/05/96	Chinese Restaurant (dim sum)	Lunch	Wanchai	No
RES-III	21/05/96	Chinese Restaurant (dim sum)	Lunch	Wanchai	No
RES-IV	31/05/96	Western Fast Food	Lunch	Wanchai	No
RES-V	11/06/96	Chinese Restaurant (dim sum)	Lunch	Wanchai	No
RES-VI	13/06/96	Chinese Restaurant (dim sum)	Lunch	Shek Kip Mei	No
RES-VII	18/06/96	Chinese Hot Pot	Dinner	Happy Valley	Yes
RES-VIII	02/07/96	Chinese Restaurant (dim sum)	Lunch	North Point	No
RES-IX	15/10/96	Pizza	Lunch	Tai Koo Shing	No
RES-X	04/07/96	Pub	Happy Hour	Wanchai	No
RES-XI	05/07/96	Chinese Banquet	Banquet dinner	Causeway Bay	No
RES-XII	29/07/96	Western Steak House	Dinner	Wanchai	No
RES-XIII	01/08/96	Hamburger Fast Food	Lunch	Wanchai	No
RES-XIV	22/08/96	Indian/ Thai	Dinner	Causeway Bay	No
RES-XV	05/09/96	Mongolian Barbecue	Dinner	Tsim Sha Tsui	Yes
RES-XVI	06/09/96	Pub	Happy Hour	Central	No
RES-XVII	10/09/96	Korean Barbecue	Dinner	Central	Yes
RES-XVIII	16/09/96	Japanese	Dinner	Causeway Bay	No
RES-XIX	29/10/96	Karaoke Pub	Dinner	Wanchai	No
RES-XX	30/10/96	Western Buffet	Dinner	Central	No

VII-2 Summary of the 5 Selected Cinemas

Date	Code	District	Age	Size
28/09/96	CIN-I	Wanchai	>20	Small
02/07/96	CIN-II	Mong Kok	6-10	Small
24/08/96	CIN-III	Shatin	6-10	Small
29/09/96	CIN-IV	Causeway Bay	>20	Large
29/09/96	CIN-V	Tsim Sha Tsui	<5	Large

PM3006517521

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

VII-3 Summary of the 5 Selected Shopping Mall

Date	Code	Description	District
19/10/97	SHO-I	Shopping Mall	Tsuen Wan
22/09/97	SHO-II	Shopping Mall	Shatin
26/10/97	SHO-III	Shopping Mall	Causeway Bay
11/08/97	SHO-IV	Shopping Mall	Lok Fu
07/07/97	SHO-V	Shopping Mall	Lam Tin
06/10/97	SHO-VI	Shopping Mall	Sheung Shui
13/10/97	SHO-VII	Shopping Mall	Kwai Fong
20/10/97	SHO-VIII	Department Store	Sheung Wan

VII-4 Survey Schedule for Platform and Concourse

Location	Date	Time	Station	Remark
Platform	4 Oct 96 (Friday)	0830 - 1700	A	Lower platform
	11 Oct 96 (Friday)	0830 - 1700	B	Lower platform
Concourse	5 Oct 96 (Saturday)	1200 - 2000	C	Up end & Down end
	12 Oct 96 (Saturday)	1200 - 2000	B	East end & West end

VII-5 Survey Schedule for Train Compartment

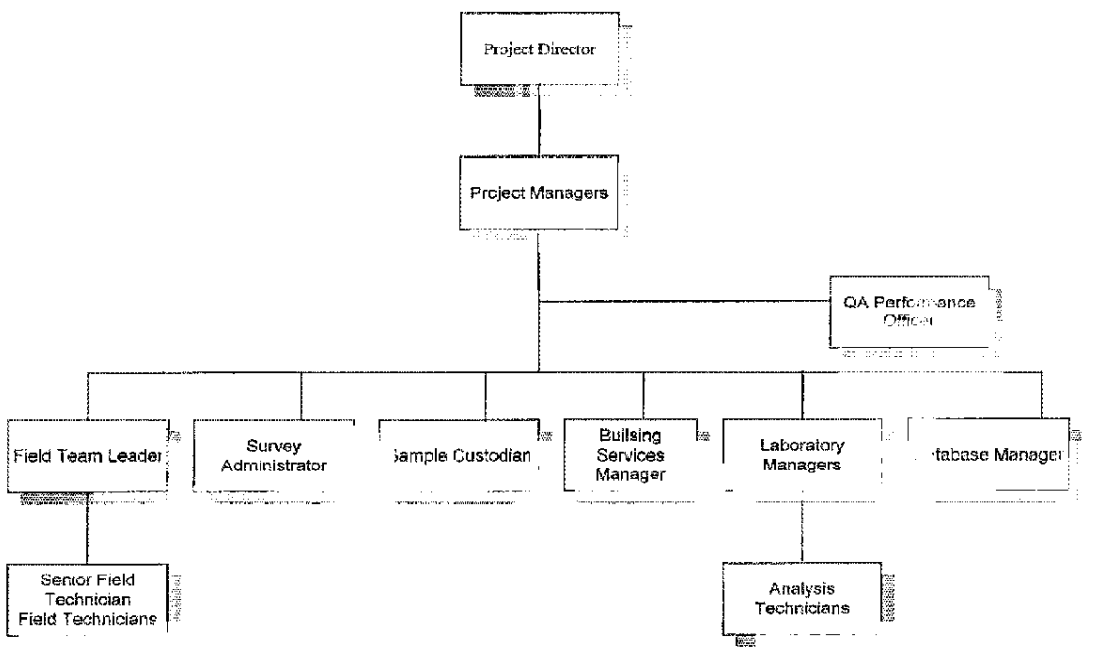
Date	Survey No.	Time	Condition
4 Oct 96 (Friday)	I	0830 - 0900	Peak hour
	II	0950 - 1020	Off peak hour
	III	1740 - 1805	Peak hour
11 Oct 96 (Friday)	IV	0830 - 0900	Peak hour
	V	1000 - 1025	Off peak hour
	VI	1830 - 1900	Peak hour

PM3006517522

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

VII-6 The Survey Team and the Structure of the Survey & Data Management Team

No.	Post	Responsibilities
1	Field Team Leader	Person-in-charge and interview with the building management
1	Survey Administrator	Questionnaire Survey and microbial sampling
1	Technician-in-charge	QA/QC and deployment of integrated samples
2-3	Technician	Real-time monitoring using the mobile cart, tracer gas analysis
2-3	Building Services Engineer	HVAC system and local ventilation performance measurements



PM3006517523
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX VIIIa

Correlation from Computer Printouts

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Nonparametric program
Time is Tue Mar 25 22:09:20 1997
File used: all3x.dat
Variable #79 Day sick leave in 30 days and #4 Sex
Spearmans correlation=0.1041 DOF=971 P value=0.0012
Variable #79 Day sick leave in 30 days and #5 Age
Spearmans correlation=-0.1835 DOF=950 P value=0.0000
Variable #79 Day sick leave in 30 days and #30 Colds without reason
Spearmans correlation=0.1069 DOF=890 P value=0.0014
Variable #79 Day sick leave in 30 days and #48 Eat breakfast at workstation?
Spearmans correlation=0.0854 DOF=971 P value=0.0077
Variable #79 Day sick leave in 30 days and #50 Eat snack at workstation?
Spearmans correlation=0.0810 DOF=971 P value=0.0115
Variable #79 Day sick leave in 30 days and #51 Eat none at workstation?
Spearmans correlation=-0.1005 DOF=971 P value=0.0017
Variable #79 Day sick leave in 30 days and #52 Cook in office?
Spearmans correlation=-0.0988 DOF=968 P value=0.0021
Variable #79 Day sick leave in 30 days and #54 Openable window?
Spearmans correlation=0.1020 DOF=965 P value=0.0015
Variable #79 Day sick leave in 30 days and #55 Open as wish?
Spearmans correlation=0.1489 DOF=401 P value=0.0027
Variable #79 Day sick leave in 30 days and #56 Defusers have lot of dust?
Spearmans correlation=-0.1207 DOF=959 P value=0.0002
Variable #79 Day sick leave in 30 days and #77 Cold/flu times
Spearmans correlation=0.3730 DOF=970 P value=0.0000
Variable #79 Day sick leave in 30 days and #78 Cold/flu days
Spearmans correlation=0.4115 DOF=967 P value=0.0000
Variable #79 Day sick leave in 30 days and #81 Comfort in Office
Spearmans correlation=0.1451 DOF=971 P value=0.0000
Variable #79 Day sick leave in 30 days and #89 Odour: In-house Kitchen
Spearmans correlation=0.0847 DOF=971 P value=0.0082
Variable #79 Day sick leave in 30 days and #90 Odour: Mould
Spearmans correlation=0.0984 DOF=971 P value=0.0021
Variable #79 Day sick leave in 30 days and #91 Odour: Tobacco Smoke
Spearmans correlation=0.0902 DOF=971 P value=0.0049
Variable #79 Day sick leave in 30 days and #93 Odour: Unknown
Spearmans correlation=0.0885 DOF=971 P value=0.0057
Variable #79 Day sick leave in 30 days and #98 Dust problem in work
Spearmans correlation=-0.1304 DOF=969 P value=0.0000
Variable #79 Day sick leave in 30 days and #101 Dry eye No
Spearmans correlation=-0.1132 DOF=971 P value=0.0004
Variable #79 Day sick leave in 30 days and #103 Dry eye during work
Spearmans correlation=0.1279 DOF=971 P value=0.0001
Variable #79 Day sick leave in 30 days and #109 Teary eye No
Spearmans correlation=-0.1441 DOF=971 P value=0.0000
Variable #79 Day sick leave in 30 days and #111 Teary eye during work
Spearmans correlation=0.1428 DOF=971 P value=0.0000
Variable #79 Day sick leave in 30 days and #113 Blurry eye No
Spearmans correlation=-0.1563 DOF=971 P value=0.0000
Variable #79 Day sick leave in 30 days and #115 Blurry eye during work
Spearmans correlation=0.1645 DOF=971 P value=0.0000
Variable #79 Day sick leave in 30 days and #117 Eyedrops per day
Spearmans correlation=0.1549 DOF=971 P value=0.0000
Variable #79 Day sick leave in 30 days and #118 No Eyedrops at work

PM3006517525

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=-0.1554 DOF=971 P value=0.0000
Variable #79 Day sick leave in 30 days and #121 Winter temperature in work
Spearmans correlation=-0.0906 DOF=947 P value=0.0052
Variable #79 Day sick leave in 30 days and #122 Summer humidity in work
Spearmans correlation=-0.0926 DOF=967 P value=0.0039
Variable #79 Day sick leave in 30 days and #123 Winter humidity in work
Spearmans correlation=-0.0935 DOF=942 P value=0.0040
Variable #79 Day sick leave in 30 days and #152 Occupancy density/100m2
Spearmans correlation=0.0887 DOF=899 P value=0.0077
Variable #79 Day sick leave in 30 days and #166 Occupant density
Spearmans correlation=-0.0945 DOF=971 P value=0.0032
Variable #79 Day sick leave in 30 days and #194 Sick Building report
Spearmans correlation=-0.1262 DOF=969 P value=0.0001
Variable #79 Day sick leave in 30 days and #210 Air change
Spearmans correlation=0.1078 DOF=917 P value=0.0011
Variable #80 Air Quality in Office and #4 Sex
Spearmans correlation=0.1759 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #10 Cigarettes per day at work
Spearmans correlation=-0.1136 DOF=969 P value=0.0004
Variable #80 Air Quality in Office and #11 Cigarettes per day
Spearmans correlation=-0.1181 DOF=969 P value=0.0002
Variable #80 Air Quality in Office and #26 Bronchitis
Spearmans correlation=0.0981 DOF=931 P value=0.0027
Variable #80 Air Quality in Office and #28 Skin problem
Spearmans correlation=0.0964 DOF=938 P value=0.0031
Variable #80 Air Quality in Office and #30 Colds without reason
Spearmans correlation=0.2332 DOF=888 P value=0.0000
Variable #80 Air Quality in Office and #31 Colds after office
Spearmans correlation=0.2269 DOF=343 P value=0.0000
Variable #80 Air Quality in Office and #32 Dust sensitivity
Spearmans correlation=0.1648 DOF=918 P value=0.0000
Variable #80 Air Quality in Office and #33 Dust sensitivity after office
Spearmans correlation=0.3029 DOF=193 P value=0.0000
Variable #80 Air Quality in Office and #34 Mould allergy
Spearmans correlation=0.1267 DOF=929 P value=0.0001
Variable #80 Air Quality in Office and #35 Mould allergy after office
Spearmans correlation=0.3797 DOF=146 P value=0.0000
Variable #80 Air Quality in Office and #48 Eat breakfast at workstation?
Spearmans correlation=0.1108 DOF=969 P value=0.0005
Variable #80 Air Quality in Office and #50 Eat snack at workstation?
Spearmans correlation=0.0865 DOF=969 P value=0.0070
Variable #80 Air Quality in Office and #51 Eat none at workstation?
Spearmans correlation=-0.1284 DOF=969 P value=0.0001
Variable #80 Air Quality in Office and #52 Cook in office?
Spearmans correlation=-0.0971 DOF=966 P value=0.0025
Variable #80 Air Quality in Office and #56 Defusers have lot of dust?
Spearmans correlation=-0.4140 DOF=957 P value=0.0000
Variable #80 Air Quality in Office and #77 Cold/flu times
Spearmans correlation=0.2888 DOF=968 P value=0.0000
Variable #80 Air Quality in Office and #78 Cold/flu days
Spearmans correlation=0.2742 DOF=965 P value=0.0000
Variable #80 Air Quality in Office and #81 Comfort in Office
Spearmans correlation=0.5820 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #82 Cleanliness in Office

PM3006517526

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.4718 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #84 Odour: Restaurant Chimney
Spearmans correlation=0.1136 DOF=969 P value=0.0004
Variable #80 Air Quality in Office and #86 Odour: Body Odour
Spearmans correlation=0.1246 DOF=969 P value=0.0001
Variable #80 Air Quality in Office and #88 Odour: Cleaning Agents
Spearmans correlation=0.1349 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #89 Odour: In-house Kitchen
Spearmans correlation=0.1171 DOF=969 P value=0.0003
Variable #80 Air Quality in Office and #90 Odour: Mould
Spearmans correlation=0.1962 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #91 Odour: Tobacco Smoke
Spearmans correlation=0.1410 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #92 Odour: Chemicals
Spearmans correlation=0.0844 DOF=969 P value=0.0085
Variable #80 Air Quality in Office and #93 Odour: Unknown
Spearmans correlation=0.1831 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #98 Dust problem in work
Spearmans correlation=-0.3880 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #99 Noise problem in work
Spearmans correlation=-0.2068 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #101 Dry eye No
Spearmans correlation=-0.2419 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #103 Dry eye during work
Spearmans correlation=0.2934 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #105 Hot eye No
Spearmans correlation=-0.2338 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #107 Hot eye during work
Spearmans correlation=0.2444 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #109 Teary eye No
Spearmans correlation=-0.1759 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #111 Teary eye during work
Spearmans correlation=0.1975 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #113 Blurry eye No
Spearmans correlation=-0.2609 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #115 Blurry eye during work
Spearmans correlation=0.2588 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #120 Summer temperature in work
Spearmans correlation=0.1780 DOF=967 P value=0.0000
Variable #80 Air Quality in Office and #122 Summer humidity in work
Spearmans correlation=-0.1349 DOF=966 P value=0.0000
Variable #80 Air Quality in Office and #123 Winter humidity in work
Spearmans correlation=-0.2450 DOF=941 P value=0.0000
Variable #80 Air Quality in Office and #124 Summer ventilation in work
Spearmans correlation=0.3126 DOF=967 P value=0.0000
Variable #80 Air Quality in Office and #125 Winter ventilation in work
Spearmans correlation=0.1908 DOF=946 P value=0.0000
Variable #80 Air Quality in Office and #142 Total Months
Spearmans correlation=0.1497 DOF=962 P value=0.0000
Variable #80 Air Quality in Office and #152 Occupancy density/100m2
Spearmans correlation=0.1713 DOF=897 P value=0.0000
Variable #80 Air Quality in Office and #155 New carpet
Spearmans correlation=0.1680 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #156 Reroofing

PM3006517527

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.1180 DOF=969 P value=0.0002
Variable #80 Air Quality in Office and #158 Repartitioning
Spearmans correlation=0.1280 DOF=969 P value=0.0001
Variable #80 Air Quality in Office and #166 Occupant density
Spearmans correlation=-0.1226 DOF=969 P value=0.0001
Variable #80 Air Quality in Office and #169 No. of fluorescent
Spearmans correlation=0.1098 DOF=969 P value=0.0006
Variable #80 Air Quality in Office and #173 Total no. of lighting elements
Spearmans correlation=0.1139 DOF=969 P value=0.0004
Variable #80 Air Quality in Office and #174 No. of supply air vents
Spearmans correlation=0.1499 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #177 Floor covering
Spearmans correlation=0.1137 DOF=968 P value=0.0004
Variable #80 Air Quality in Office and #181 Natural wood product
Spearmans correlation=0.1074 DOF=969 P value=0.0008
Variable #80 Air Quality in Office and #182 No. of chairs
Spearmans correlation=0.2073 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #184 No. of photocopier (dry)
Spearmans correlation=0.1438 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #187 No. of computers
Spearmans correlation=0.1775 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #188 No. of fax machines
Spearmans correlation=0.1419 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #193 No. of fans
Spearmans correlation=0.1943 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #194 Sick Building report
Spearmans correlation=-0.9163 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #195 Carbon dioxide
Spearmans correlation=0.0959 DOF=969 P value=0.0028
Variable #80 Air Quality in Office and #202 Dustborne bacteria
Spearmans correlation=-0.1986 DOF=349 P value=0.0002
Variable #80 Air Quality in Office and #203 Dustborne fungi
Spearmans correlation=-0.2843 DOF=352 P value=0.0000
Variable #80 Air Quality in Office and #205 Endotoxin
Spearmans correlation=-0.2037 DOF=352 P value=0.0001
Variable #80 Air Quality in Office and #207 Temperature
Spearmans correlation=0.2234 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #208 Relative Humidity
Spearmans correlation=-0.2026 DOF=969 P value=0.0000
Variable #80 Air Quality in Office and #210 Air change
Spearmans correlation=0.0905 DOF=915 P value=0.0061
Variable #80 Air Quality in Office and #215 Carbon Tet external
Spearmans correlation=-0.1611 DOF=963 P value=0.0000
Variable #80 Air Quality in Office and #219 HCHO ext
Spearmans correlation=-0.1156 DOF=969 P value=0.0003
Variable #80 Air Quality in Office and #220 Mpxylene ext
Spearmans correlation=-0.1067 DOF=963 P value=0.0009
Variable #80 Air Quality in Office and #224 OXylene ext
Spearmans correlation=-0.0935 DOF=963 P value=0.0036
Variable #80 Air Quality in Office and #228 Trichloro ext
Spearmans correlation=-0.1133 DOF=963 P value=0.0004
Variable #80 Air Quality in Office and #229 Bacteria
Spearmans correlation=0.1001 DOF=719 P value=0.0071
Variable #80 Air Quality in Office and #231 Choloro

PM3006517528
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.1549 DOF=846 P value=0.0000
Variable #80 Air Quality in Office and #232 Carbon Tet
Spearmans correlation=0.1579 DOF=846 P value=0.0000
Variable #80 Air Quality in Office and #236 HCHO
Spearmans correlation=-0.2482 DOF=729 P value=0.0000
Variable #80 Air Quality in Office and #239 O3
Spearmans correlation=-0.1266 DOF=737 P value=0.0006
Variable #80 Air Quality in Office and #240 ODichloro
Spearmans correlation=-0.0914 DOF=846 P value=0.0077
Variable #80 Air Quality in Office and #244 Toluene
Spearmans correlation=-0.1215 DOF=843 P value=0.0004

Variable #133 Eye and #4 Sex
Spearmans correlation=0.0966 DOF=971 P value=0.0026
Variable #133 Eye and #10 Cigarettes per day at work
Spearmans correlation=-0.0852 DOF=971 P value=0.0078
Variable #133 Eye and #24 Hay fever/pollen allergy
Spearmans correlation=0.1187 DOF=946 P value=0.0002
Variable #133 Eye and #26 Bronchitis
Spearmans correlation=0.0982 DOF=932 P value=0.0027
Variable #133 Eye and #28 Skin problem
Spearmans correlation=0.0883 DOF=940 P value=0.0067
Variable #133 Eye and #30 Colds without reason
Spearmans correlation=0.2188 DOF=890 P value=0.0000
Variable #133 Eye and #32 Dust sensitivity
Spearmans correlation=0.0948 DOF=920 P value=0.0040
Variable #133 Eye and #34 Mould allergy
Spearmans correlation=0.1002 DOF=930 P value=0.0022
Variable #133 Eye and #56 Defusers have lot of dust?
Spearmans correlation=-0.2310 DOF=959 P value=0.0000
Variable #133 Eye and #77 Cold/flu times
Spearmans correlation=0.1935 DOF=970 P value=0.0000
Variable #133 Eye and #78 Cold/flu days
Spearmans correlation=0.2372 DOF=967 P value=0.0000
Variable #133 Eye and #81 Comfort in Office
Spearmans correlation=0.1536 DOF=971 P value=0.0000
Variable #133 Eye and #82 Cleanliness in Office
Spearmans correlation=0.1182 DOF=969 P value=0.0002
Variable #133 Eye and #86 Odour: Body Odour
Spearmans correlation=0.0826 DOF=971 P value=0.0099
Variable #133 Eye and #88 Odour: Cleaning Agents
Spearmans correlation=0.1006 DOF=971 P value=0.0017
Variable #133 Eye and #92 Odour: Chemicals
Spearmans correlation=0.0845 DOF=971 P value=0.0084
Variable #133 Eye and #93 Odour: Unknown
Spearmans correlation=0.1150 DOF=971 P value=0.0003
Variable #133 Eye and #98 Dust problem in work
Spearmans correlation=-0.2142 DOF=969 P value=0.0000
Variable #133 Eye and #99 Noise problem in work
Spearmans correlation=-0.1287 DOF=969 P value=0.0001
Variable #133 Eye and #101 Dry eye No
Spearmans correlation=-0.3705 DOF=971 P value=0.0000
Variable #133 Eye and #103 Dry eye during work
Spearmans correlation=0.4038 DOF=971 P value=0.0000

PM3006517529

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #133 Eye and #105 Hot eye No
Spearmans correlation=-0.1528 DOF=971 P value=0.0000
Variable #133 Eye and #107 Hot eye during work
Spearmans correlation=0.1729 DOF=971 P value=0.0000
Variable #133 Eye and #109 Teary eye No
Spearmans correlation=-0.2999 DOF=971 P value=0.0000
Variable #133 Eye and #111 Teary eye during work
Spearmans correlation=0.3271 DOF=971 P value=0.0000
Variable #133 Eye and #113 Blurry eye No
Spearmans correlation=-0.2885 DOF=971 P value=0.0000
Variable #133 Eye and #115 Blurry eye during work
Spearmans correlation=0.2870 DOF=971 P value=0.0000
Variable #133 Eye and #117 Eyedrops per day
Spearmans correlation=0.1057 DOF=971 P value=0.0010
Variable #133 Eye and #118 No Eyedrops at work
Spearmans correlation=-0.0976 DOF=971 P value=0.0023
Variable #133 Eye and #122 Summer humidity in work
Spearmans correlation=-0.0893 DOF=967 P value=0.0054
Variable #133 Eye and #123 Winter humidity in work
Spearmans correlation=-0.1205 DOF=942 P value=0.0002
Variable #133 Eye and #124 Summer ventilation in work
Spearmans correlation=0.0939 DOF=968 P value=0.0034
Variable #133 Eye and #155 New carpet
Spearmans correlation=0.0983 DOF=971 P value=0.0021
Variable #133 Eye and #158 Repartitioning
Spearmans correlation=0.1146 DOF=971 P value=0.0003
Variable #133 Eye and #163 Bathroom Cleaner
Spearmans correlation=0.0913 DOF=924 P value=0.0054
Variable #133 Eye and #173 Total no. of lighting elements
Spearmans correlation=0.0843 DOF=971 P value=0.0086
Variable #133 Eye and #182 No. of chairs
Spearmans correlation=0.1181 DOF=971 P value=0.0002
Variable #133 Eye and #187 No. of computers
Spearmans correlation=0.0963 DOF=971 P value=0.0026
Variable #133 Eye and #194 Sick Building report
Spearmans correlation=-0.2370 DOF=969 P value=0.0000
Variable #133 Eye and #224 OXylene ext
Spearmans correlation=-0.0830 DOF=965 P value=0.0098
Variable #133 Eye and #225 RSP ext
Spearmans correlation=-0.1036 DOF=971 P value=0.0012
Variable #133 Eye and #226 Tetrachloroeth ext
Spearmans correlation=0.0823 DOF=971 P value=0.0102
Variable #133 Eye and #228 Trichloro ext
Spearmans correlation=-0.1027 DOF=965 P value=0.0014
Variable #133 Eye and #236 HCHO
Spearmans correlation=-0.1236 DOF=731 P value=0.0008

Variable #134 Nose and #5 Age
Spearmans correlation=-0.1046 DOF=950 P value=0.0012
Variable #134 Nose and #30 Colds without reason
Spearmans correlation=0.2332 DOF=890 P value=0.0000
Variable #134 Nose and #32 Dust sensitivity
Spearmans correlation=0.1689 DOF=920 P value=0.0000
Variable #134 Nose and #33 Dust sensitivity after office

PM3006517530

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.2308 DOF=193 P value=0.0012
Variable #134 Nose and #40 Floor
Spearmans correlation=0.1000 DOF=965 P value=0.0018
Variable #134 Nose and #56 Defusers have lot of dust?
Spearmans correlation=-0.1556 DOF=959 P value=0.0000
Variable #134 Nose and #77 Cold/flu times
Spearmans correlation=0.3532 DOF=970 P value=0.0000
Variable #134 Nose and #78 Cold/flu days
Spearmans correlation=0.3462 DOF=967 P value=0.0000
Variable #134 Nose and #81 Comfort in Office
Spearmans correlation=0.1558 DOF=971 P value=0.0000
Variable #134 Nose and #82 Cleanliness in Office
Spearmans correlation=0.1264 DOF=969 P value=0.0001
Variable #134 Nose and #86 Odour: Body Odour
Spearmans correlation=0.1373 DOF=971 P value=0.0000
Variable #134 Nose and #90 Odour: Mould
Spearmans correlation=0.1407 DOF=971 P value=0.0000
Variable #134 Nose and #91 Odour: Tobacco Smoke
Spearmans correlation=0.0973 DOF=971 P value=0.0024
Variable #134 Nose and #92 Odour: Chemicals
Spearmans correlation=0.0841 DOF=971 P value=0.0086
Variable #134 Nose and #98 Dust problem in work
Spearmans correlation=-0.1769 DOF=969 P value=0.0000
Variable #134 Nose and #99 Noise problem in work
Spearmans correlation=-0.1343 DOF=969 P value=0.0000
Variable #134 Nose and #101 Dry eye No
Spearmans correlation=-0.2055 DOF=971 P value=0.0000
Variable #134 Nose and #103 Dry eye during work
Spearmans correlation=0.2092 DOF=971 P value=0.0000
Variable #134 Nose and #105 Hot eye No
Spearmans correlation=-0.0925 DOF=971 P value=0.0039
Variable #134 Nose and #106 Hot eye before work
Spearmans correlation=0.0860 DOF=971 P value=0.0072
Variable #134 Nose and #107 Hot eye during work
Spearmans correlation=0.0942 DOF=971 P value=0.0033
Variable #134 Nose and #109 Teary eye No
Spearmans correlation=-0.2246 DOF=971 P value=0.0000
Variable #134 Nose and #111 Teary eye during work
Spearmans correlation=0.2445 DOF=971 P value=0.0000
Variable #134 Nose and #113 Blurry eye No
Spearmans correlation=-0.1859 DOF=971 P value=0.0000
Variable #134 Nose and #114 Blurry eye before work
Spearmans correlation=0.0931 DOF=971 P value=0.0037
Variable #134 Nose and #115 Blurry eye during work
Spearmans correlation=0.1596 DOF=971 P value=0.0000
Variable #134 Nose and #123 Winter humidity in work
Spearmans correlation=-0.1265 DOF=942 P value=0.0001
Variable #134 Nose and #124 Summer ventilation in work
Spearmans correlation=0.0883 DOF=968 P value=0.0059
Variable #134 Nose and #156 Reroofing
Spearmans correlation=0.0867 DOF=971 P value=0.0068
Variable #134 Nose and #158 Repartitioning
Spearmans correlation=0.0968 DOF=971 P value=0.0025
Variable #134 Nose and #160 Window Cleaner

PM3006517531
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=-0.0869 DOF=924 P value=0.0082
Variable #134 Nose and #180 Pressed wood product
Spearmans correlation=0.1010 DOF=971 P value=0.0016
Variable #134 Nose and #182 No. of chairs
Spearmans correlation=0.0815 DOF=971 P value=0.0110
Variable #134 Nose and #187 No. of computers
Spearmans correlation=0.0903 DOF=971 P value=0.0048
Variable #134 Nose and #194 Sick Building report
Spearmans correlation=-0.2512 DOF=969 P value=0.0000
Variable #134 Nose and #203 Dustborne fungi
Spearmans correlation=-0.1526 DOF=352 P value=0.0040
Variable #134 Nose and #205 Endotoxin
Spearmans correlation=-0.1600 DOF=352 P value=0.0025
Variable #134 Nose and #225 RSP ext
Spearmans correlation=-0.1097 DOF=971 P value=0.0006
Variable #134 Nose and #226 Tetrachloroeth ext
Spearmans correlation=0.1132 DOF=971 P value=0.0004
Variable #134 Nose and #229 Bacteria
Spearmans correlation=0.0996 DOF=721 P value=0.0074
Variable #134 Nose and #231 Choloro
Spearmans correlation=0.1114 DOF=848 P value=0.0011
Variable #134 Nose and #238 NO2
Spearmans correlation=-0.1002 DOF=738 P value=0.0064

Variable #135 Throat and #4 Sex
Spearmans correlation=0.1002 DOF=971 P value=0.0018
Variable #135 Throat and #5 Age
Spearmans correlation=-0.1052 DOF=950 P value=0.0011
Variable #135 Throat and #23 Asthma after this office
Spearmans correlation=0.3098 DOF=125 P value=0.0004
Variable #135 Throat and #26 Bronchitis
Spearmans correlation=0.1161 DOF=932 P value=0.0004
Variable #135 Throat and #30 Colds without reason
Spearmans correlation=0.1984 DOF=890 P value=0.0000
Variable #135 Throat and #56 Defusers have lot of dust?
Spearmans correlation=-0.2013 DOF=959 P value=0.0000
Variable #135 Throat and #77 Cold/flu times
Spearmans correlation=0.2523 DOF=970 P value=0.0000
Variable #135 Throat and #78 Cold/flu days
Spearmans correlation=0.2624 DOF=967 P value=0.0000
Variable #135 Throat and #81 Comfort in Office
Spearmans correlation=0.1679 DOF=971 P value=0.0000
Variable #135 Throat and #82 Cleanliness in Office
Spearmans correlation=0.1491 DOF=969 P value=0.0000
Variable #135 Throat and #86 Odour: Body Odour
Spearmans correlation=0.1030 DOF=971 P value=0.0013
Variable #135 Throat and #89 Odour: In-house Kitchen
Spearmans correlation=0.1103 DOF=971 P value=0.0006
Variable #135 Throat and #90 Odour: Mould
Spearmans correlation=0.0963 DOF=971 P value=0.0026
Variable #135 Throat and #91 Odour: Tobacco Smoke
Spearmans correlation=0.1029 DOF=971 P value=0.0013
Variable #135 Throat and #98 Dust problem in work
Spearmans correlation=-0.1902 DOF=969 P value=0.0000

PM3006517532

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #135 Throat and #99 Noise problem in work
Spearmans correlation=-0.1086 DOF=969 P value=0.0007
Variable #135 Throat and #101 Dry eye No
Spearmans correlation=-0.2284 DOF=971 P value=0.0000
Variable #135 Throat and #103 Dry eye during work
Spearmans correlation=0.2811 DOF=971 P value=0.0000
Variable #135 Throat and #105 Hot eye No
Spearmans correlation=-0.1246 DOF=971 P value=0.0001
Variable #135 Throat and #107 Hot eye during work
Spearmans correlation=0.1424 DOF=971 P value=0.0000
Variable #135 Throat and #109 Teary eye No
Spearmans correlation=-0.1571 DOF=971 P value=0.0000
Variable #135 Throat and #111 Teary eye during work
Spearmans correlation=0.1933 DOF=971 P value=0.0000
Variable #135 Throat and #113 Blurry eye No
Spearmans correlation=-0.2227 DOF=971 P value=0.0000
Variable #135 Throat and #115 Blurry eye during work
Spearmans correlation=0.1839 DOF=971 P value=0.0000
Variable #135 Throat and #122 Summer humidity in work
Spearmans correlation=-0.1306 DOF=967 P value=0.0000
Variable #135 Throat and #123 Winter humidity in work
Spearmans correlation=-0.1503 DOF=942 P value=0.0000
Variable #135 Throat and #168 Total partition
Spearmans correlation=-0.0928 DOF=971 P value=0.0038
Variable #135 Throat and #194 Sick Building report
Spearmans correlation=-0.2306 DOF=969 P value=0.0000
Variable #135 Throat and #199 Pesticide DI
Spearmans correlation=0.3529 DOF=71 P value=0.0022
Variable #135 Throat and #203 Dustborne fungi
Spearmans correlation=-0.1385 DOF=352 P value=0.0091
Variable #135 Throat and #207 Temperature
Spearmans correlation=0.0921 DOF=971 P value=0.0040
Variable #135 Throat and #232 Carbon Tet
Spearmans correlation=0.1066 DOF=848 P value=0.0019
Variable #135 Throat and #236 HCHO
Spearmans correlation=-0.1118 DOF=731 P value=0.0024

Variable #136 Headache and #4 Sex
Spearmans correlation=0.1543 DOF=971 P value=0.0000
Variable #136 Headache and #28 Skin problem
Spearmans correlation=0.1030 DOF=940 P value=0.0015
Variable #136 Headache and #30 Colds without reason
Spearmans correlation=0.2029 DOF=890 P value=0.0000
Variable #136 Headache and #31 Colds after office
Spearmans correlation=0.1435 DOF=343 P value=0.0076
Variable #136 Headache and #32 Dust sensitivity
Spearmans correlation=0.1012 DOF=920 P value=0.0021
Variable #136 Headache and #56 Defusers have lot of dust?
Spearmans correlation=-0.1977 DOF=959 P value=0.0000
Variable #136 Headache and #77 Cold/flu times
Spearmans correlation=0.2431 DOF=970 P value=0.0000
Variable #136 Headache and #78 Cold/flu days
Spearmans correlation=0.2458 DOF=967 P value=0.0000
Variable #136 Headache and #81 Comfort in Office

PM3006517533

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.1822 DOF=971 P value=0.0000
Variable #136 Headache and #82 Cleanliness in Office
Spearmans correlation=0.1356 DOF=969 P value=0.0000
Variable #136 Headache and #86 Odour: Body Odour
Spearmans correlation=0.1102 DOF=971 P value=0.0006
Variable #136 Headache and #88 Odour: Cleaning Agents
Spearmans correlation=0.0897 DOF=971 P value=0.0051
Variable #136 Headache and #90 Odour: Mould
Spearmans correlation=0.1071 DOF=971 P value=0.0008
Variable #136 Headache and #91 Odour: Tobacco Smoke
Spearmans correlation=0.0823 DOF=971 P value=0.0103
Variable #136 Headache and #98 Dust problem in work
Spearmans correlation=-0.1418 DOF=969 P value=0.0000
Variable #136 Headache and #101 Dry eye No
Spearmans correlation=-0.1897 DOF=971 P value=0.0000
Variable #136 Headache and #103 Dry eye during work
Spearmans correlation=0.2411 DOF=971 P value=0.0000
Variable #136 Headache and #105 Hot eye No
Spearmans correlation=-0.1618 DOF=971 P value=0.0000
Variable #136 Headache and #106 Hot eye before work
Spearmans correlation=0.0922 DOF=971 P value=0.0040
Variable #136 Headache and #107 Hot eye during work
Spearmans correlation=0.1672 DOF=971 P value=0.0000
Variable #136 Headache and #109 Teary eye No
Spearmans correlation=-0.1508 DOF=971 P value=0.0000
Variable #136 Headache and #111 Teary eye during work
Spearmans correlation=0.1763 DOF=971 P value=0.0000
Variable #136 Headache and #113 Blurry eye No
Spearmans correlation=-0.2052 DOF=971 P value=0.0000
Variable #136 Headache and #115 Blurry eye during work
Spearmans correlation=0.2009 DOF=971 P value=0.0000
Variable #136 Headache and #122 Summer humidity in work
Spearmans correlation=-0.0913 DOF=967 P value=0.0045
Variable #136 Headache and #123 Winter humidity in work
Spearmans correlation=-0.1316 DOF=942 P value=0.0001
Variable #136 Headache and #194 Sick Building report
Spearmans correlation=-0.2133 DOF=969 P value=0.0000
Variable #136 Headache and #232 Carbon Tet
Spearmans correlation=0.0894 DOF=848 P value=0.0091

Variable #137 Skin Allergy and #30 Colds without reason
Spearmans correlation=0.1204 DOF=890 P value=0.0003
Variable #137 Skin Allergy and #34 Mould allergy
Spearmans correlation=0.1042 DOF=930 P value=0.0014
Variable #137 Skin Allergy and #56 Defusers have lot of dust?
Spearmans correlation=-0.1651 DOF=959 P value=0.0000
Variable #137 Skin Allergy and #77 Cold/flu times
Spearmans correlation=0.1718 DOF=970 P value=0.0000
Variable #137 Skin Allergy and #78 Cold/flu days
Spearmans correlation=0.1708 DOF=967 P value=0.0000
Variable #137 Skin Allergy and #81 Comfort in Office
Spearmans correlation=0.1287 DOF=971 P value=0.0001
Variable #137 Skin Allergy and #82 Cleanliness in Office
Spearmans correlation=0.1174 DOF=969 P value=0.0002

PM3006517534
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #137 Skin Allergy and #88 Odour: Cleaning Agents
Spearmans correlation=0.1198 DOF=971 P value=0.0002
Variable #137 Skin Allergy and #90 Odour: Mould
Spearmans correlation=0.1277 DOF=971 P value=0.0001
Variable #137 Skin Allergy and #91 Odour: Tobacco Smoke
Spearmans correlation=0.1076 DOF=971 P value=0.0008
Variable #137 Skin Allergy and #93 Odour: Unknown
Spearmans correlation=0.1545 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #95 Odour: Neighbourhood Cooking
Spearmans correlation=0.1557 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #96 Odour: Renovation
Spearmans correlation=0.0938 DOF=971 P value=0.0034
Variable #137 Skin Allergy and #98 Dust problem in work
Spearmans correlation=-0.1578 DOF=969 P value=0.0000
Variable #137 Skin Allergy and #101 Dry eye No
Spearmans correlation=-0.1460 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #103 Dry eye during work
Spearmans correlation=0.1747 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #105 Hot eye No
Spearmans correlation=-0.1727 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #107 Hot eye during work
Spearmans correlation=0.1698 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #109 Teary eye No
Spearmans correlation=-0.1115 DOF=971 P value=0.0005
Variable #137 Skin Allergy and #111 Teary eye during work
Spearmans correlation=0.1404 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #113 Blurry eye No
Spearmans correlation=-0.1406 DOF=971 P value=0.0000
Variable #137 Skin Allergy and #115 Blurry eye during work
Spearmans correlation=0.1051 DOF=971 P value=0.0010
Variable #137 Skin Allergy and #123 Winter humidity in work
Spearmans correlation=-0.1338 DOF=942 P value=0.0000
Variable #137 Skin Allergy and #125 Winter ventilation in work
Spearmans correlation=0.0903 DOF=947 P value=0.0054
Variable #137 Skin Allergy and #194 Sick Building report
Spearmans correlation=-0.1988 DOF=969 P value=0.0000
Variable #137 Skin Allergy and #232 Carbon Tet
Spearmans correlation=0.0932 DOF=848 P value=0.0066

Variable #138 Tired and #4 Sex
Spearmans correlation=0.1505 DOF=971 P value=0.0000
Variable #138 Tired and #5 Age
Spearmans correlation=-0.1258 DOF=950 P value=0.0001
Variable #138 Tired and #30 Colds without reason
Spearmans correlation=0.1795 DOF=890 P value=0.0000
Variable #138 Tired and #50 Eat snack at workstation?
Spearmans correlation=0.1114 DOF=971 P value=0.0005
Variable #138 Tired and #52 Cook in office?
Spearmans correlation=-0.1177 DOF=968 P value=0.0002
Variable #138 Tired and #56 Defusers have lot of dust?
Spearmans correlation=-0.1862 DOF=959 P value=0.0000
Variable #138 Tired and #77 Cold/flu times
Spearmans correlation=0.2183 DOF=970 P value=0.0000
Variable #138 Tired and #78 Cold/flu days

PM3006517535
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.2362 DOF=967 P value=0.0000
Variable #138 Tired and #81 Comfort in Office
Spearmans correlation=0.1992 DOF=971 P value=0.0000
Variable #138 Tired and #82 Cleanliness in Office
Spearmans correlation=0.1576 DOF=969 P value=0.0000
Variable #138 Tired and #90 Odour: Mould
Spearmans correlation=0.0881 DOF=971 P value=0.0060
Variable #138 Tired and #93 Odour: Unknown
Spearmans correlation=0.1234 DOF=971 P value=0.0001
Variable #138 Tired and #98 Dust problem in work
Spearmans correlation=-0.1889 DOF=969 P value=0.0000
Variable #138 Tired and #99 Noise problem in work
Spearmans correlation=-0.1326 DOF=969 P value=0.0000
Variable #138 Tired and #101 Dry eye No
Spearmans correlation=-0.2500 DOF=971 P value=0.0000
Variable #138 Tired and #102 Dry eye before work
Spearmans correlation=0.1109 DOF=971 P value=0.0005
Variable #138 Tired and #103 Dry eye during work
Spearmans correlation=0.2608 DOF=971 P value=0.0000
Variable #138 Tired and #105 Hot eye No
Spearmans correlation=-0.1082 DOF=971 P value=0.0007
Variable #138 Tired and #107 Hot eye during work
Spearmans correlation=0.1420 DOF=971 P value=0.0000
Variable #138 Tired and #109 Teary eye No
Spearmans correlation=-0.2083 DOF=971 P value=0.0000
Variable #138 Tired and #111 Teary eye during work
Spearmans correlation=0.2164 DOF=971 P value=0.0000
Variable #138 Tired and #113 Blurry eye No
Spearmans correlation=-0.2550 DOF=971 P value=0.0000
Variable #138 Tired and #115 Blurry eye during work
Spearmans correlation=0.2421 DOF=971 P value=0.0000
Variable #138 Tired and #121 Winter temperature in work
Spearmans correlation=-0.0891 DOF=947 P value=0.0060
Variable #138 Tired and #123 Winter humidity in work
Spearmans correlation=-0.1395 DOF=942 P value=0.0000
Variable #138 Tired and #124 Summer ventilation in work
Spearmans correlation=0.0831 DOF=968 P value=0.0096
Variable #138 Tired and #158 Repartitioning
Spearmans correlation=0.0841 DOF=971 P value=0.0087
Variable #138 Tired and #173 Total no. of lighting elements
Spearmans correlation=0.0825 DOF=971 P value=0.0101
Variable #138 Tired and #174 No. of supply air vents
Spearmans correlation=0.0936 DOF=971 P value=0.0035
Variable #138 Tired and #182 No. of chairs
Spearmans correlation=0.1251 DOF=971 P value=0.0001
Variable #138 Tired and #187 No. of computers
Spearmans correlation=0.1127 DOF=971 P value=0.0004
Variable #138 Tired and #194 Sick Building report
Spearmans correlation=-0.2416 DOF=969 P value=0.0000
Variable #138 Tired and #197 Pesticide CH
Spearmans correlation=-0.3042 DOF=71 P value=0.0089
Variable #138 Tired and #207 Temperature
Spearmans correlation=0.0949 DOF=971 P value=0.0030
Variable #138 Tired and #215 Carbon Tet external

PM3006517536

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=-0.0950 DOF=965 P value=0.0031
Variable #138 Tired and #236 HCHO
Spearmans correlation=-0.1379 DOF=731 P value=0.0002

Variable #139 Sick Building Index and #4 Sex
Spearmans correlation=0.1671 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #5 Age
Spearmans correlation=-0.1503 DOF=950 P value=0.0000
Variable #139 Sick Building Index and #10 Cigarettes per day at work
Spearmans correlation=-0.0996 DOF=971 P value=0.0019
Variable #139 Sick Building Index and #11 Cigarettes per day
Spearmans correlation=-0.0979 DOF=971 P value=0.0022
Variable #139 Sick Building Index and #26 Bronchitis
Spearmans correlation=0.0943 DOF=932 P value=0.0039
Variable #139 Sick Building Index and #28 Skin problem
Spearmans correlation=0.1159 DOF=940 P value=0.0004
Variable #139 Sick Building Index and #30 Colds without reason
Spearmans correlation=0.2831 DOF=890 P value=0.0000
Variable #139 Sick Building Index and #31 Colds after office
Spearmans correlation=0.1587 DOF=343 P value=0.0031
Variable #139 Sick Building Index and #32 Dust sensitivity
Spearmans correlation=0.1417 DOF=920 P value=0.0000
Variable #139 Sick Building Index and #33 Dust sensitivity after office
Spearmans correlation=0.2142 DOF=193 P value=0.0026
Variable #139 Sick Building Index and #34 Mould allergy
Spearmans correlation=0.0873 DOF=930 P value=0.0076
Variable #139 Sick Building Index and #48 Eat breakfast at workstation?
Spearmans correlation=0.0912 DOF=971 P value=0.0044
Variable #139 Sick Building Index and #50 Eat snack at workstation?
Spearmans correlation=0.1126 DOF=971 P value=0.0004
Variable #139 Sick Building Index and #51 Eat none at workstation?
Spearmans correlation=-0.0991 DOF=971 P value=0.0020
Variable #139 Sick Building Index and #52 Cook in office?
Spearmans correlation=-0.1034 DOF=968 P value=0.0013
Variable #139 Sick Building Index and #56 Defusers have lot of dust?
Spearmans correlation=-0.2690 DOF=959 P value=0.0000
Variable #139 Sick Building Index and #77 Cold/flu times
Spearmans correlation=0.3453 DOF=970 P value=0.0000
Variable #139 Sick Building Index and #78 Cold/flu days
Spearmans correlation=0.3637 DOF=967 P value=0.0000
Variable #139 Sick Building Index and #81 Comfort in Office
Spearmans correlation=0.2473 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #82 Cleanliness in Office
Spearmans correlation=0.2005 DOF=969 P value=0.0000
Variable #139 Sick Building Index and #86 Odour: Body Odour
Spearmans correlation=0.1369 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #88 Odour: Cleaning Agents
Spearmans correlation=0.1041 DOF=971 P value=0.0011
Variable #139 Sick Building Index and #89 Odour: In-house Kitchen
Spearmans correlation=0.1178 DOF=971 P value=0.0002
Variable #139 Sick Building Index and #90 Odour: Mould
Spearmans correlation=0.1372 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #91 Odour: Tobacco Smoke
Spearmans correlation=0.1115 DOF=971 P value=0.0005

PM3006517537

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #139 Sick Building Index and #93 Odour: Unknown
Spearmans correlation=0.1385 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #98 Dust problem in work
Spearmans correlation=-0.2666 DOF=969 P value=0.0000
Variable #139 Sick Building Index and #99 Noise problem in work
Spearmans correlation=-0.1648 DOF=969 P value=0.0000
Variable #139 Sick Building Index and #101 Dry eye No
Spearmans correlation=-0.3472 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #103 Dry eye during work
Spearmans correlation=0.3911 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #105 Hot eye No
Spearmans correlation=-0.1718 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #106 Hot eye before work
Spearmans correlation=0.0877 DOF=971 P value=0.0062
Variable #139 Sick Building Index and #107 Hot eye during work
Spearmans correlation=0.1987 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #109 Teary eye No
Spearmans correlation=-0.2881 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #111 Teary eye during work
Spearmans correlation=0.3179 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #113 Blurry eye No
Spearmans correlation=-0.3292 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #114 Blurry eye before work
Spearmans correlation=0.0899 DOF=971 P value=0.0050
Variable #139 Sick Building Index and #115 Blurry eye during work
Spearmans correlation=0.2990 DOF=971 P value=0.0000
Variable #139 Sick Building Index and #122 Summer humidity in work
Spearmans correlation=-0.1460 DOF=967 P value=0.0000
Variable #139 Sick Building Index and #123 Winter humidity in work
Spearmans correlation=-0.1948 DOF=942 P value=0.0000
Variable #139 Sick Building Index and #124 Summer ventilation in work
Spearmans correlation=0.1038 DOF=968 P value=0.0012
Variable #139 Sick Building Index and #158 Repartitioning
Spearmans correlation=0.0997 DOF=971 P value=0.0019
Variable #139 Sick Building Index and #173 Total no. of lighting elements
Spearmans correlation=0.0877 DOF=971 P value=0.0062
Variable #139 Sick Building Index and #174 No. of supply air vents
Spearmans correlation=0.0872 DOF=971 P value=0.0065
Variable #139 Sick Building Index and #182 No. of chairs
Spearmans correlation=0.1252 DOF=971 P value=0.0001
Variable #139 Sick Building Index and #187 No. of computers
Spearmans correlation=0.1148 DOF=971 P value=0.0003
Variable #139 Sick Building Index and #193 No. of fans
Spearmans correlation=0.0856 DOF=971 P value=0.0076
Variable #139 Sick Building Index and #194 Sick Building report
Spearmans correlation=-0.3236 DOF=969 P value=0.0000
Variable #139 Sick Building Index and #203 Dustborne fungi
Spearmans correlation=-0.1557 DOF=352 P value=0.0033
Variable #139 Sick Building Index and #207 Temperature
Spearmans correlation=0.1129 DOF=971 P value=0.0004
Variable #139 Sick Building Index and #225 RSP ext
Spearmans correlation=-0.1071 DOF=971 P value=0.0008
Variable #139 Sick Building Index and #226 Tetrachloroeth ext
Spearmans correlation=-0.0204 DOF=950 P value=0.5287

PM3006517538

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #139 Sick Building Index and #228 Trichloro ext
Spearmans correlation=0.0898 DOF=848 P value=0.0088
Variable #139 Sick Building Index and #232 Carbon Tet
Spearmans correlation=0.1174 DOF=848 P value=0.0006
Variable #139 Sick Building Index and #236 HCHO
Spearmans correlation=-0.1374 DOF=731 P value=0.0002

13March 97

PM3006517539

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX VIIIb

Correlation from Computer Printouts

(Revised Building Symptoms Index (BSI) on Skin Allergy)

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Nonparametric program
Time is Thu Apr 10 19:23:45 1997
File used: all3a.dat
Variable #301 Skin Itch and #4 Sex
Spearmans correlation=0.1494 DOF=971 P value=0.0000
Variable #301 Skin Itch and #5 Age
Spearmans correlation=-0.1077 DOF=950 P value=0.0009
Variable #301 Skin Itch and #10 Cigarettes per day at work
Spearmans correlation=-0.0433 DOF=971 P value=0.1768
Variable #301 Skin Itch and #11 Cigarettes per day
Spearmans correlation=-0.0524 DOF=971 P value=0.1025
Variable #301 Skin Itch and #22 Asthma
Spearmans correlation=-0.0528 DOF=947 P value=0.1043
Variable #301 Skin Itch and #23 Asthma after this office
Spearmans correlation=-0.0310 DOF=125 P value=0.7297
Variable #301 Skin Itch and #24 Hay fever/pollen allergy
Spearmans correlation=0.0309 DOF=946 P value=0.3417
Variable #301 Skin Itch and #25 Hay fever after office
Spearmans correlation=0.1003 DOF=123 P value=0.2655
Variable #301 Skin Itch and #26 Bronchitis
Spearmans correlation=0.0604 DOF=932 P value=0.0649
Variable #301 Skin Itch and #27 Bronchitis after office
Spearmans correlation=-0.0307 DOF=199 P value=0.6658
Variable #301 Skin Itch and #28 Skin problem
Spearmans correlation=0.0435 DOF=940 P value=0.1820
Variable #301 Skin Itch and #29 Skin Problem after office
Spearmans correlation=-0.0980 DOF=165 P value=0.2079
Variable #301 Skin Itch and #30 Colds without reason
Spearmans correlation=0.1612 DOF=890 P value=0.0000
Variable #301 Skin Itch and #31 Colds after office
Spearmans correlation=0.0436 DOF=343 P value=0.4192
Variable #301 Skin Itch and #32 Dust sensitivity
Spearmans correlation=0.1180 DOF=920 P value=0.0003
Variable #301 Skin Itch and #33 Dust sensitivity after office
Spearmans correlation=0.0230 DOF=193 P value=0.7493
Variable #301 Skin Itch and #34 Mould allergy
Spearmans correlation=0.0868 DOF=930 P value=0.0080
Variable #301 Skin Itch and #35 Mould allergy after office
Spearmans correlation=-0.0077 DOF=146 P value=0.9264
Variable #301 Skin Itch and #36 Work overtime2
Spearmans correlation=-0.0324 DOF=970 P value=0.3126
Variable #301 Skin Itch and #37 Hrs per week overtime
Spearmans correlation=-0.0331 DOF=971 P value=0.3027
Variable #301 Skin Itch and #40 Floor
Spearmans correlation=-0.0254 DOF=965 P value=0.4299
Variable #301 Skin Itch and #48 Eat breakfast at workstation?
Spearmans correlation=0.0789 DOF=971 P value=0.0139
Variable #301 Skin Itch and #49 Eat lunch at workstation?
Spearmans correlation=0.0478 DOF=971 P value=0.1364
Variable #301 Skin Itch and #50 Eat snack at workstation?
Spearmans correlation=0.1014 DOF=971 P value=0.0015
Variable #301 Skin Itch and #51 Eat none at workstation?
Spearmans correlation=-0.0536 DOF=971 P value=0.0944
Variable #301 Skin Itch and #52 Cook in office?

PM3006517541
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=-0.0974 DOF=968 P value=0.0024
Variable #301 Skin Itch and #53 Pantry for cooking
Spearmans correlation=0.0337 DOF=613 P value=0.4037
Variable #301 Skin Itch and #54 Openable window?
Spearmans correlation=-0.0437 DOF=965 P value=0.1742
Variable #301 Skin Itch and #55 Open as wish?
Spearmans correlation=-0.0458 DOF=401 P value=0.3591
Variable #301 Skin Itch and #56 Defusers have lot of dust?
Spearmans correlation=-0.2246 DOF=959 P value=0.0000
Variable #301 Skin Itch and #61 How many smokers?
Spearmans correlation=0.0435 DOF=971 P value=0.1753
Variable #301 Skin Itch and #69 How far photocopier
Spearmans correlation=-0.0128 DOF=965 P value=0.6916
Variable #301 Skin Itch and #70 How far laserprinter
Spearmans correlation=0.0750 DOF=902 P value=0.0241
Variable #301 Skin Itch and #71 How far fax machine
Spearmans correlation=0.0200 DOF=955 P value=0.5376
Variable #301 Skin Itch and #77 Cold/flu times
Spearmans correlation=0.1886 DOF=970 P value=0.0000
Variable #301 Skin Itch and #78 Cold/flu days
Spearmans correlation=0.1959 DOF=967 P value=0.0000
Variable #301 Skin Itch and #81 Comfort in Office
Spearmans correlation=0.1757 DOF=971 P value=0.0000
Variable #301 Skin Itch and #82 Cleanliness in Office
Spearmans correlation=0.1995 DOF=969 P value=0.0000
Variable #301 Skin Itch and #84 Odour: Restaurant Chimney
Spearmans correlation=0.0728 DOF=971 P value=0.0232
Variable #301 Skin Itch and #85 Odour: Traffic Emission
Spearmans correlation=-0.0232 DOF=971 P value=0.4700
Variable #301 Skin Itch and #86 Odour: Body Odour
Spearmans correlation=0.0680 DOF=971 P value=0.0338
Variable #301 Skin Itch and #87 Odour: Burning of Essence
Spearmans correlation=-0.0101 DOF=971 P value=0.7541
Variable #301 Skin Itch and #88 Odour: Cleaning Agents
Spearmans correlation=0.1458 DOF=971 P value=0.0000
Variable #301 Skin Itch and #89 Odour: In-house Kitchen
Spearmans correlation=0.1141 DOF=971 P value=0.0004
Variable #301 Skin Itch and #90 Odour: Mould
Spearmans correlation=0.0792 DOF=971 P value=0.0134
Variable #301 Skin Itch and #91 Odour: Tobacco Smoke
Spearmans correlation=0.0923 DOF=971 P value=0.0040
Variable #301 Skin Itch and #92 Odour: Chemicals
Spearmans correlation=0.0303 DOF=971 P value=0.3456
Variable #301 Skin Itch and #93 Odour: Unknown
Spearmans correlation=0.0776 DOF=971 P value=0.0155
Variable #301 Skin Itch and #94 Odour: Industrial Emissions
Spearmans correlation=-0.0155 DOF=971 P value=0.6294
Variable #301 Skin Itch and #95 Odour: Neighbourhood Cooking
Spearmans correlation=0.0674 DOF=971 P value=0.0356
Variable #301 Skin Itch and #96 Odour: Renovation
Spearmans correlation=0.0730 DOF=971 P value=0.0228
Variable #301 Skin Itch and #97 Odour: Others
Spearmans correlation=-0.0028 DOF=971 P value=0.9297
Variable #301 Skin Itch and #98 Dust problem in work
Spearmans correlation=-0.2025 DOF=969 P value=0.0000

PM3006517542
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #301 Skin Itch and #99 Noise problem in work
Spearmans correlation=-0.1241 DOF=969 P value=0.0001
Variable #301 Skin Itch and #101 Dry eye No
Spearmans correlation=-0.1855 DOF=971 P value=0.0000
Variable #301 Skin Itch and #102 Dry eye before work
Spearmans correlation=0.0077 DOF=971 P value=0.8099
Variable #301 Skin Itch and #103 Dry eye during work
Spearmans correlation=0.2174 DOF=971 P value=0.0000
Variable #301 Skin Itch and #104 Dry eye at night
Spearmans correlation=-0.0347 DOF=971 P value=0.2792
Variable #301 Skin Itch and #105 Hot eye No
Spearmans correlation=-0.1153 DOF=971 P value=0.0003
Variable #301 Skin Itch and #106 Hot eye before work
Spearmans correlation=0.0290 DOF=971 P value=0.3660
Variable #301 Skin Itch and #107 Hot eye during work
Spearmans correlation=0.1086 DOF=971 P value=0.0007
Variable #301 Skin Itch and #108 Hot eye at night
Spearmans correlation=0.0078 DOF=971 P value=0.8078
Variable #301 Skin Itch and #109 Teary eye No
Spearmans correlation=-0.1980 DOF=971 P value=0.0000
Variable #301 Skin Itch and #110 Teary eye before work
Spearmans correlation=-0.0060 DOF=971 P value=0.8508
Variable #301 Skin Itch and #111 Teary eye during work
Spearmans correlation=0.2183 DOF=971 P value=0.0000
Variable #301 Skin Itch and #112 Teary eye at night
Spearmans correlation=0.0244 DOF=971 P value=0.4462
Variable #301 Skin Itch and #113 Blurry eye No
Spearmans correlation=-0.2251 DOF=971 P value=0.0000
Variable #301 Skin Itch and #114 Blurry eye before work
Spearmans correlation=0.0505 DOF=971 P value=0.1154
Variable #301 Skin Itch and #115 Blurry eye during work
Spearmans correlation=0.1883 DOF=971 P value=0.0000
Variable #301 Skin Itch and #116 Blurry eye at night
Spearmans correlation=0.0338 DOF=971 P value=0.2915
Variable #301 Skin Itch and #117 Eyedrops per day
Spearmans correlation=0.0459 DOF=971 P value=0.1525
Variable #301 Skin Itch and #118 No Eyedrops at work
Spearmans correlation=-0.0492 DOF=971 P value=0.1251
Variable #301 Skin Itch and #120 Summer temperature in work
Spearmans correlation=-0.0167 DOF=968 P value=0.6028
Variable #301 Skin Itch and #121 Winter temperature in work
Spearmans correlation=-0.0230 DOF=947 P value=0.4789
Variable #301 Skin Itch and #122 Summer humidity in work
Spearmans correlation=-0.1910 DOF=967 P value=0.0000
Variable #301 Skin Itch and #123 Winter humidity in work
Spearmans correlation=-0.2274 DOF=942 P value=0.0000
Variable #301 Skin Itch and #124 Summer ventilation in work
Spearmans correlation=0.0715 DOF=968 P value=0.0260
Variable #301 Skin Itch and #125 Winter ventilation in work
Spearmans correlation=0.0768 DOF=947 P value=0.0179
Variable #301 Skin Itch and #141 Hrs/week
Spearmans correlation=0.0314 DOF=968 P value=0.3281
Variable #301 Skin Itch and #142 Total Months
Spearmans correlation=0.0220 DOF=964 P value=0.4952
Variable #301 Skin Itch and #151 Renovation with 3 mons

PM3006517543

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.0343 DOF=971 P value=0.2849
Variable #301 Skin Itch and #152 Occupancy density/100m2
Spearmans correlation=0.0575 DOF=899 P value=0.0847
Variable #301 Skin Itch and #153 Pre-occupied space
Spearmans correlation=0.0178 DOF=971 P value=0.5787
Variable #301 Skin Itch and #154 Painting
Spearmans correlation=0.0025 DOF=971 P value=0.9372
Variable #301 Skin Itch and #155 New carpet
Spearmans correlation=0.0410 DOF=971 P value=0.2011
Variable #301 Skin Itch and #156 Reroofing
Spearmans correlation=0.0419 DOF=971 P value=0.1911
Variable #301 Skin Itch and #157 New furniture
Spearmans correlation=-0.0179 DOF=971 P value=0.5777
Variable #301 Skin Itch and #158 Repartitioning
Spearmans correlation=0.0750 DOF=971 P value=0.0192
Variable #301 Skin Itch and #160 Window Cleaner
Spearmans correlation=0.0475 DOF=924 P value=0.1483
Variable #301 Skin Itch and #161 Floor Wax
Spearmans correlation=0.0097 DOF=924 P value=0.7691
Variable #301 Skin Itch and #162 Furniture Cleaner
Spearmans correlation=0.0373 DOF=924 P value=0.2570
Variable #301 Skin Itch and #163 Bathroom Cleaner
Spearmans correlation=0.0727 DOF=924 P value=0.0271
Variable #301 Skin Itch and #166 Occupant density
Spearmans correlation=-0.0271 DOF=971 P value=0.3981
Variable #301 Skin Itch and #167 Ceiling height
Spearmans correlation=0.0124 DOF=971 P value=0.6981
Variable #301 Skin Itch and #168 Total partition
Spearmans correlation=-0.0480 DOF=971 P value=0.1347
Variable #301 Skin Itch and #169 No. of fluorescent
Spearmans correlation=0.0213 DOF=971 P value=0.5066
Variable #301 Skin Itch and #170 No. of incandescent
Spearmans correlation=0.0229 DOF=971 P value=0.4758
Variable #301 Skin Itch and #171 No. of high intensity
Spearmans correlation=0.0300 DOF=971 P value=0.3493
Variable #301 Skin Itch and #172 No. of desk lamps
Spearmans correlation=0.0132 DOF=971 P value=0.6800
Variable #301 Skin Itch and #173 Total no. of lighting elements
Spearmans correlation=0.0502 DOF=971 P value=0.1179
Variable #301 Skin Itch and #174 No. of supply air vents
Spearmans correlation=0.0244 DOF=971 P value=0.4476
Variable #301 Skin Itch and #175 No. of return air vents
Spearmans correlation=0.0033 DOF=971 P value=0.9172
Variable #301 Skin Itch and #177 Floor covering
Spearmans correlation=0.0157 DOF=970 P value=0.6244
Variable #301 Skin Itch and #178 Suspended ceiling
Spearmans correlation=0.0000 DOF=960 P value=1.0000
Variable #301 Skin Itch and #180 Pressed wood product
Spearmans correlation=-0.0127 DOF=971 P value=0.6918
Variable #301 Skin Itch and #181 Natural wood product
Spearmans correlation=-0.0022 DOF=971 P value=0.9455
Variable #301 Skin Itch and #182 No. of chairs
Spearmans correlation=0.0736 DOF=971 P value=0.0217
Variable #301 Skin Itch and #183 No. of Dry-clean fabrics
Spearmans correlation=-0.0086 DOF=971 P value=0.7887

PM3006517544

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #301 Skin Itch and #184 No. of photocopier (dry)
Spearmans correlation=0.0316 DOF=971 P value=0.3253
Variable #301 Skin Itch and #185 No. of photocopier (wet)
Spearmans correlation=0.0020 DOF=971 P value=0.9503
Variable #301 Skin Itch and #186 No. of laser printers
Spearmans correlation=0.0060 DOF=971 P value=0.8526
Variable #301 Skin Itch and #187 No. of computers
Spearmans correlation=0.0475 DOF=971 P value=0.1385
Variable #301 Skin Itch and #188 No. of fax machines
Spearmans correlation=0.0454 DOF=971 P value=0.1566
Variable #301 Skin Itch and #189 No. of air cleaners
Spearmans correlation=-0.0361 DOF=971 P value=0.2605
Variable #301 Skin Itch and #190 No. of heater
Spearmans correlation=0.0000 DOF=971 P value=1.0000
Variable #301 Skin Itch and #191 No. of humidier
Spearmans correlation=0.0000 DOF=971 P value=1.0000
Variable #301 Skin Itch and #192 No. dehumidier
Spearmans correlation=0.0000 DOF=971 P value=1.0000
Variable #301 Skin Itch and #193 No. of fans
Spearmans correlation=-0.0085 DOF=971 P value=0.7901
Variable #301 Skin Itch and #194 Sick Building report
Spearmans correlation=-0.2344 DOF=969 P value=0.0000
Variable #301 Skin Itch and #195 Carbon monoxide
Spearmans correlation=-0.0103 DOF=971 P value=0.7492
Variable #301 Skin Itch and #196 Carbon dioxide
Spearmans correlation=-0.0273 DOF=971 P value=0.3957
Variable #301 Skin Itch and #197 Nicotine
Spearmans correlation=-0.0922 DOF=59 P value=0.4796
Variable #301 Skin Itch and #198 Pesticide CH
Spearmans correlation=-0.1845 DOF=71 P value=0.1181
Variable #301 Skin Itch and #199 Pesticide DC
Spearmans correlation=-0.1080 DOF=71 P value=0.3629
Variable #301 Skin Itch and #200 Pesticide DI
Spearmans correlation=0.0217 DOF=71 P value=0.8551
Variable #301 Skin Itch and #201 Pesticide DZ
Spearmans correlation=-0.1080 DOF=71 P value=0.3629
Variable #301 Skin Itch and #202 Pesticide TP
Spearmans correlation=-0.0669 DOF=71 P value=0.5741
Variable #301 Skin Itch and #203 Dustborne bacteria
Spearmans correlation=-0.0673 DOF=349 P value=0.2087
Variable #301 Skin Itch and #204 Dustborne fungi
Spearmans correlation=-0.0956 DOF=352 P value=0.0723
Variable #301 Skin Itch and #205 Glucan
Spearmans correlation=-0.1283 DOF=349 P value=0.0162
Variable #301 Skin Itch and #206 Endotoxin
Spearmans correlation=-0.0725 DOF=352 P value=0.1734
Variable #301 Skin Itch and #207 Dust mite
Spearmans correlation=0.0534 DOF=137 P value=0.5324
Variable #301 Skin Itch and #208 Temperature
Spearmans correlation=0.0261 DOF=971 P value=0.4167
Variable #301 Skin Itch and #209 Relative Humidity
Spearmans correlation=-0.0023 DOF=971 P value=0.9434
Variable #301 Skin Itch and #210 Draught
Spearmans correlation=0.0310 DOF=956 P value=0.3376
Variable #301 Skin Itch and #211 Air change

PM3006517545
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.0203 DOF=917 P value=0.5392
Variable #301 Skin Itch and #212 Site
Spearmans correlation=-0.0133 DOF=971 P value=0.6792
Variable #301 Skin Itch and #213 Bacteria ext
Spearmans correlation=0.0298 DOF=945 P value=0.3604
Variable #301 Skin Itch and #214 Benzene ext
Spearmans correlation=-0.0024 DOF=965 P value=0.9396
Variable #301 Skin Itch and #215 Chloroform ext
Spearmans correlation=0.0272 DOF=965 P value=0.3984
Variable #301 Skin Itch and #216 Carbon Tet external
Spearmans correlation=-0.0225 DOF=965 P value=0.4840
Variable #301 Skin Itch and #217 Ethyl Benzene ext
Spearmans correlation=-0.0173 DOF=965 P value=0.5917
Variable #301 Skin Itch and #218 ETS ext
Spearmans correlation=-0.0171 DOF=956 P value=0.5974
Variable #301 Skin Itch and #219 Fungi ext
Spearmans correlation=-0.0314 DOF=971 P value=0.3283
Variable #301 Skin Itch and #220 HCHO ext
Spearmans correlation=-0.0738 DOF=971 P value=0.0213
Variable #301 Skin Itch and #221 Mpxylene ext
Spearmans correlation=-0.0014 DOF=965 P value=0.9660
Variable #301 Skin Itch and #222 NO2 ext
Spearmans correlation=-0.0431 DOF=971 P value=0.1788
Variable #301 Skin Itch and #223 O3 ext
Spearmans correlation=-0.0047 DOF=971 P value=0.8842
Variable #301 Skin Itch and #224 ODichloro ext
Spearmans correlation=-0.0096 DOF=965 P value=0.7645
Variable #301 Skin Itch and #225 OXylene ext
Spearmans correlation=-0.0421 DOF=965 P value=0.1913
Variable #301 Skin Itch and #226 RSP ext
Spearmans correlation=-0.0470 DOF=971 P value=0.1431
Variable #301 Skin Itch and #227 Tetrachloroeth ext
Spearmans correlation=-0.0370 DOF=971 P value=0.2483
Variable #301 Skin Itch and #228 Toluene ext
Spearmans correlation=-0.0619 DOF=950 P value=0.0564
Variable #301 Skin Itch and #229 Trichloro ext
Spearmans correlation=-0.0630 DOF=965 P value=0.0500
Variable #301 Skin Itch and #230 Bacteria
Spearmans correlation=0.0006 DOF=721 P value=0.9874
Variable #301 Skin Itch and #231 Benzene
Spearmans correlation=0.0308 DOF=848 P value=0.3700
Variable #301 Skin Itch and #232 Choloro
Spearmans correlation=0.0164 DOF=848 P value=0.6322
Variable #301 Skin Itch and #233 Carbon Tet
Spearmans correlation=0.0730 DOF=848 P value=0.0333
Variable #301 Skin Itch and #234 Ethyl Benzene
Spearmans correlation=-0.0289 DOF=848 P value=0.4007
Variable #301 Skin Itch and #235 ETS
Spearmans correlation=0.0078 DOF=607 P value=0.8468
Variable #301 Skin Itch and #236 Fungi
Spearmans correlation=-0.0529 DOF=738 P value=0.1508
Variable #301 Skin Itch and #237 HCHO
Spearmans correlation=-0.1194 DOF=731 P value=0.0012
Variable #301 Skin Itch and #238 Mpxylene
Spearmans correlation=-0.0480 DOF=848 P value=0.1618

PM3006517546
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #301 Skin Itch and #239 NO2
Spearmans correlation=0.0111 DOF=738 P value=0.7621
Variable #301 Skin Itch and #240 O3
Spearmans correlation=-0.0161 DOF=739 P value=0.6626
Variable #301 Skin Itch and #241 ODichloro
Spearmans correlation=-0.0255 DOF=848 P value=0.4578
Variable #301 Skin Itch and #242 OXylene
Spearmans correlation=-0.0479 DOF=848 P value=0.1629
Variable #301 Skin Itch and #243 RSP
Spearmans correlation=-0.0656 DOF=738 P value=0.0746
Variable #301 Skin Itch and #244 Tetrachloroeth
Spearmans correlation=-0.0468 DOF=848 P value=0.1730
Variable #301 Skin Itch and #245 Toluene
Spearmans correlation=-0.0458 DOF=845 P value=0.1828
Variable #301 Skin Itch and #246 Trichloro
Spearmans correlation=0.0406 DOF=848 P value=0.2375

Variable #302 SBI new and #4 Sex
Spearmans correlation=0.1762 DOF=971 P value=0.0000
Variable #302 SBI new and #5 Age
Spearmans correlation=-0.1584 DOF=950 P value=0.0000
Variable #302 SBI new and #10 Cigarettes per day at work
Spearmans correlation=-0.0982 DOF=971 P value=0.0022
Variable #302 SBI new and #11 Cigarettes per day
Spearmans correlation=-0.0938 DOF=971 P value=0.0034
Variable #302 SBI new and #22 Asthma
Spearmans correlation=0.0087 DOF=947 P value=0.7897
Variable #302 SBI new and #23 Asthma after this office
Spearmans correlation=0.1065 DOF=125 P value=0.2332
Variable #302 SBI new and #24 Hay fever/pollen allergy
Spearmans correlation=0.0738 DOF=946 P value=0.0230
Variable #302 SBI new and #25 Hay fever after office
Spearmans correlation=0.1045 DOF=123 P value=0.2459
Variable #302 SBI new and #26 Bronchitis
Spearmans correlation=0.0952 DOF=932 P value=0.0036
Variable #302 SBI new and #27 Bronchitis after office
Spearmans correlation=0.1268 DOF=199 P value=0.0729
Variable #302 SBI new and #28 Skin problem
Spearmans correlation=0.1091 DOF=940 P value=0.0008
Variable #302 SBI new and #29 Skin Problem after office
Spearmans correlation=0.1100 DOF=165 P value=0.1569
Variable #302 SBI new and #30 Colds without reason
Spearmans correlation=0.2778 DOF=890 P value=0.0000
Variable #302 SBI new and #31 Colds after office
Spearmans correlation=0.1465 DOF=343 P value=0.0064
Variable #302 SBI new and #32 Dust sensitivity
Spearmans correlation=0.1449 DOF=920 P value=0.0000
Variable #302 SBI new and #33 Dust sensitivity after office
Spearmans correlation=0.1950 DOF=193 P value=0.0063
Variable #302 SBI new and #34 Mould allergy
Spearmans correlation=0.0880 DOF=930 P value=0.0072
Variable #302 SBI new and #35 Mould allergy after office
Spearmans correlation=0.0809 DOF=146 P value=0.3286
Variable #302 SBI new and #36 Work overtime2
Spearmans correlation=-0.0191 DOF=970 P value=0.5522

PM3006517547
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #302 SBI new and #37 Hrs per week overtime
Spearmans correlation=-0.0084 DOF=971 P value=0.7934
Variable #302 SBI new and #40 Floor
Spearmans correlation=0.0474 DOF=965 P value=0.1405
Variable #302 SBI new and #48 Eat breakfast at workstation?
Spearmans correlation=0.0972 DOF=971 P value=0.0024
Variable #302 SBI new and #49 Eat lunch at workstation?
Spearmans correlation=0.0540 DOF=971 P value=0.0925
Variable #302 SBI new and #50 Eat snack at workstation?
Spearmans correlation=0.1206 DOF=971 P value=0.0002
Variable #302 SBI new and #51 Eat none at workstation?
Spearmans correlation=-0.1001 DOF=971 P value=0.0018
Variable #302 SBI new and #52 Cook in office?
Spearmans correlation=-0.1105 DOF=968 P value=0.0006
Variable #302 SBI new and #53 Pantry for cooking
Spearmans correlation=0.0188 DOF=613 P value=0.6425
Variable #302 SBI new and #54 Openable window?
Spearmans correlation=-0.0039 DOF=965 P value=0.9024
Variable #302 SBI new and #55 Open as wish?
Spearmans correlation=-0.0122 DOF=401 P value=0.8074
Variable #302 SBI new and #56 Defusers have lot of dust?
Spearmans correlation=-0.2761 DOF=959 P value=0.0000
Variable #302 SBI new and #61 How many smokers?
Spearmans correlation=0.0444 DOF=971 P value=0.1664
Variable #302 SBI new and #69 How far photocopier
Spearmans correlation=-0.0315 DOF=965 P value=0.3275
Variable #302 SBI new and #70 How far laserprinter
Spearmans correlation=-0.0163 DOF=902 P value=0.6253
Variable #302 SBI new and #71 How far fax machine
Spearmans correlation=-0.0292 DOF=955 P value=0.3674
Variable #302 SBI new and #77 Cold/flu times
Spearmans correlation=0.3401 DOF=970 P value=0.0000
Variable #302 SBI new and #78 Cold/flu days
Spearmans correlation=0.3593 DOF=967 P value=0.0000
Variable #302 SBI new and #81 Comfort in Office
Spearmans correlation=0.2514 DOF=971 P value=0.0000
Variable #302 SBI new and #82 Cleanliness in Office
Spearmans correlation=0.2143 DOF=969 P value=0.0000
Variable #302 SBI new and #84 Odour: Restaurant Chimney
Spearmans correlation=0.0286 DOF=971 P value=0.3736
Variable #302 SBI new and #85 Odour: Traffic Emission
Spearmans correlation=-0.0262 DOF=971 P value=0.4145
Variable #302 SBI new and #86 Odour: Body Odour
Spearmans correlation=0.1318 DOF=971 P value=0.0000
Variable #302 SBI new and #87 Odour: Burning of Essence
Spearmans correlation=-0.0218 DOF=971 P value=0.4978
Variable #302 SBI new and #88 Odour: Cleaning Agents
Spearmans correlation=0.1130 DOF=971 P value=0.0004
Variable #302 SBI new and #89 Odour: In-house Kitchen
Spearmans correlation=0.1229 DOF=971 P value=0.0001
Variable #302 SBI new and #90 Odour: Mould
Spearmans correlation=0.1315 DOF=971 P value=0.0000
Variable #302 SBI new and #91 Odour: Tobacco Smoke
Spearmans correlation=0.1166 DOF=971 P value=0.0003
Variable #302 SBI new and #92 Odour: Chemicals

PM3006517548

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.0615 DOF=971 P value=0.0553
Variable #302 SBI new and #93 Odour: Unknown
Spearmans correlation=0.1315 DOF=971 P value=0.0000
Variable #302 SBI new and #94 Odour: Industrial Emissions
Spearmans correlation=0.0095 DOF=971 P value=0.7662
Variable #302 SBI new and #95 Odour: Neighbourhood Cooking
Spearmans correlation=0.0476 DOF=971 P value=0.1377
Variable #302 SBI new and #96 Odour: Renovation
Spearmans correlation=0.0715 DOF=971 P value=0.0258
Variable #302 SBI new and #97 Odour: Others
Spearmans correlation=-0.0030 DOF=971 P value=0.9256
Variable #302 SBI new and #98 Dust problem in work
Spearmans correlation=-0.2706 DOF=969 P value=0.0000
Variable #302 SBI new and #99 Noise problem in work
Spearmans correlation=-0.1688 DOF=969 P value=0.0000
Variable #302 SBI new and #101 Dry eye No
Spearmans correlation=-0.3451 DOF=971 P value=0.0000
Variable #302 SBI new and #102 Dry eye before work
Spearmans correlation=0.0636 DOF=971 P value=0.0472
Variable #302 SBI new and #103 Dry eye during work
Spearmans correlation=0.3870 DOF=971 P value=0.0000
Variable #302 SBI new and #104 Dry eye at night
Spearmans correlation=-0.0161 DOF=971 P value=0.6164
Variable #302 SBI new and #105 Hot eye No
Spearmans correlation=-0.1680 DOF=971 P value=0.0000
Variable #302 SBI new and #106 Hot eye before work
Spearmans correlation=0.0849 DOF=971 P value=0.0081
Variable #302 SBI new and #107 Hot eye during work
Spearmans correlation=0.1919 DOF=971 P value=0.0000
Variable #302 SBI new and #108 Hot eye at night
Spearmans correlation=0.0059 DOF=971 P value=0.8541
Variable #302 SBI new and #109 Teary eye No
Spearmans correlation=-0.2924 DOF=971 P value=0.0000
Variable #302 SBI new and #110 Teary eye before work
Spearmans correlation=0.0035 DOF=971 P value=0.9131
Variable #302 SBI new and #111 Teary eye during work
Spearmans correlation=0.3200 DOF=971 P value=0.0000
Variable #302 SBI new and #112 Teary eye at night
Spearmans correlation=0.0158 DOF=971 P value=0.6217
Variable #302 SBI new and #113 Blurry eye No
Spearmans correlation=-0.3345 DOF=971 P value=0.0000
Variable #302 SBI new and #114 Blurry eye before work
Spearmans correlation=0.0918 DOF=971 P value=0.0042
Variable #302 SBI new and #115 Blurry eye during work
Spearmans correlation=0.3028 DOF=971 P value=0.0000
Variable #302 SBI new and #116 Blurry eye at night
Spearmans correlation=0.0681 DOF=971 P value=0.0336
Variable #302 SBI new and #117 Eyedrops per day
Spearmans correlation=0.0803 DOF=971 P value=0.0122
Variable #302 SBI new and #118 No Eyedrops at work
Spearmans correlation=-0.0733 DOF=971 P value=0.0223
Variable #302 SBI new and #120 Summer temperature in work
Spearmans correlation=-0.0186 DOF=968 P value=0.5627
Variable #302 SBI new and #121 Winter temperature in work
Spearmans correlation=-0.0717 DOF=947 P value=0.0272

PM3006517549
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #302 SBI new and #122 Summer humidity in work
Spearmans correlation=-0.1617 DOF=967 P value=0.0000
Variable #302 SBI new and #123 Winter humidity in work
Spearmans correlation=-0.2082 DOF=942 P value=0.0000
Variable #302 SBI new and #124 Summer ventilation in work
Spearmans correlation=0.1033 DOF=968 P value=0.0013
Variable #302 SBI new and #125 Winter ventilation in work
Spearmans correlation=0.0656 DOF=947 P value=0.0432
Variable #302 SBI new and #141 Hrs/week
Spearmans correlation=0.0402 DOF=968 P value=0.2114
Variable #302 SBI new and #142 Total Months
Spearmans correlation=0.0190 DOF=964 P value=0.5544
Variable #302 SBI new and #151 Renovation with 3 mons
Spearmans correlation=0.0139 DOF=971 P value=0.6655
Variable #302 SBI new and #152 Occupancy density/100m2
Spearmans correlation=0.0798 DOF=899 P value=0.0166
Variable #302 SBI new and #153 Pre-occupied space
Spearmans correlation=0.0643 DOF=971 P value=0.0450
Variable #302 SBI new and #154 Painting
Spearmans correlation=-0.0491 DOF=971 P value=0.1258
Variable #302 SBI new and #155 New carpet
Spearmans correlation=0.0761 DOF=971 P value=0.0176
Variable #302 SBI new and #156 Reroofing
Spearmans correlation=0.0740 DOF=971 P value=0.0209
Variable #302 SBI new and #157 New furniture
Spearmans correlation=0.0233 DOF=971 P value=0.4679
Variable #302 SBI new and #158 Repartitioning
Spearmans correlation=0.1039 DOF=971 P value=0.0012
Variable #302 SBI new and #160 Window Cleaner
Spearmans correlation=-0.0545 DOF=924 P value=0.0977
Variable #302 SBI new and #161 Floor Wax
Spearmans correlation=-0.0237 DOF=924 P value=0.4714
Variable #302 SBI new and #162 Furniture Cleaner
Spearmans correlation=0.0291 DOF=924 P value=0.3759
Variable #302 SBI new and #163 Bathroom Cleaner
Spearmans correlation=0.0580 DOF=924 P value=0.0777
Variable #302 SBI new and #166 Occupant density
Spearmans correlation=-0.0598 DOF=971 P value=0.0621
Variable #302 SBI new and #167 Ceiling height
Spearmans correlation=0.0623 DOF=971 P value=0.0521
Variable #302 SBI new and #168 Total partition
Spearmans correlation=-0.0546 DOF=971 P value=0.0886
Variable #302 SBI new and #169 No. of fluorescent
Spearmans correlation=0.0681 DOF=971 P value=0.0337
Variable #302 SBI new and #170 No. of incandescent
Spearmans correlation=-0.0353 DOF=971 P value=0.2713
Variable #302 SBI new and #171 No. of high intensity
Spearmans correlation=-0.0316 DOF=971 P value=0.3242
Variable #302 SBI new and #172 No. of desk lamps
Spearmans correlation=0.0525 DOF=971 P value=0.1017
Variable #302 SBI new and #173 Total no. of lighting elements
Spearmans correlation=0.0904 DOF=971 P value=0.0048
Variable #302 SBI new and #174 No. of supply air vents
Spearmans correlation=0.0838 DOF=971 P value=0.0089
Variable #302 SBI new and #175 No. of return air vents

PM3006517550
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.0324 DOF=971 P value=0.3129
Variable #302 SBI new and #177 Floor covering
Spearmans correlation=0.0525 DOF=970 P value=0.1020
Variable #302 SBI new and #178 Suspended ceiling
Spearmans correlation=0.0000 DOF=960 P value=1.0000
Variable #302 SBI new and #180 Pressed wood product
Spearmans correlation=0.0409 DOF=971 P value=0.2022
Variable #302 SBI new and #181 Natural wood product
Spearmans correlation=0.0441 DOF=971 P value=0.1696
Variable #302 SBI new and #182 No. of chairs
Spearmans correlation=0.1296 DOF=971 P value=0.0000
Variable #302 SBI new and #183 No. of Dry-clean fabrics
Spearmans correlation=0.0211 DOF=971 P value=0.5101
Variable #302 SBI new and #184 No. of photocopier (dry)
Spearmans correlation=0.0493 DOF=971 P value=0.1244
Variable #302 SBI new and #185 No. of photocopier (wet)
Spearmans correlation=-0.0199 DOF=971 P value=0.5356
Variable #302 SBI new and #186 No. of laser printers
Spearmans correlation=-0.0071 DOF=971 P value=0.8259
Variable #302 SBI new and #187 No. of computers
Spearmans correlation=0.1163 DOF=971 P value=0.0003
Variable #302 SBI new and #188 No. of fax machines
Spearmans correlation=0.0640 DOF=971 P value=0.0459
Variable #302 SBI new and #189 No. of air cleaners
Spearmans correlation=-0.0588 DOF=971 P value=0.0666
Variable #302 SBI new and #190 No. of heater
Spearmans correlation=0.0000 DOF=971 P value=1.0000
Variable #302 SBI new and #191 No. of humidier
Spearmans correlation=0.0000 DOF=971 P value=1.0000
Variable #302 SBI new and #192 No. dehumidier
Spearmans correlation=0.0000 DOF=971 P value=1.0000
Variable #302 SBI new and #193 No. of fans
Spearmans correlation=0.0799 DOF=971 P value=0.0127
Variable #302 SBI new and #194 Sick Building report
Spearmans correlation=-0.3268 DOF=969 P value=0.0000
Variable #302 SBI new and #195 Carbon monoxide
Spearmans correlation=-0.0551 DOF=971 P value=0.0860
Variable #302 SBI new and #196 Carbon dioxide
Spearmans correlation=0.0152 DOF=971 P value=0.6352
Variable #302 SBI new and #197 Nicotine
Spearmans correlation=-0.1215 DOF=59 P value=0.3508
Variable #302 SBI new and #198 Pesticide CH
Spearmans correlation=-0.2470 DOF=71 P value=0.0352
Variable #302 SBI new and #199 Pesticide DC
Spearmans correlation=-0.0228 DOF=71 P value=0.8483
Variable #302 SBI new and #200 Pesticide DI
Spearmans correlation=0.1671 DOF=71 P value=0.1576
Variable #302 SBI new and #201 Pesticide DZ
Spearmans correlation=-0.0228 DOF=71 P value=0.8483
Variable #302 SBI new and #202 Pesticide TP
Spearmans correlation=-0.1824 DOF=71 P value=0.1224
Variable #302 SBI new and #203 Dustborne bacteria
Spearmans correlation=-0.0536 DOF=349 P value=0.3165
Variable #302 SBI new and #204 Dustborne fungi
Spearmans correlation=-0.1554 DOF=352 P value=0.0034

PM3006517551
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Variable #302 SBI new and #205 Glucan
Spearmans correlation=-0.0847 DOF=349 P value=0.1131
Variable #302 SBI new and #206 Endotoxin
Spearmans correlation=-0.0977 DOF=352 P value=0.0663
Variable #302 SBI new and #207 Dust mite
Spearmans correlation=0.0020 DOF=137 P value=0.9816
Variable #302 SBI new and #208 Temperature
Spearmans correlation=0.1046 DOF=971 P value=0.0011
Variable #302 SBI new and #209 Relative Humidity
Spearmans correlation=-0.0738 DOF=971 P value=0.0213
Variable #302 SBI new and #210 Draught
Spearmans correlation=0.0689 DOF=956 P value=0.0331
Variable #302 SBI new and #211 Air change
Spearmans correlation=0.0276 DOF=917 P value=0.4034
Variable #302 SBI new and #212 Site
Spearmans correlation=-0.0268 DOF=971 P value=0.4040
Variable #302 SBI new and #213 Bacteria ext
Spearmans correlation=0.0262 DOF=945 P value=0.4204
Variable #302 SBI new and #214 Benzene ext
Spearmans correlation=0.0214 DOF=965 P value=0.5070
Variable #302 SBI new and #215 Chloroform ext
Spearmans correlation=-0.0090 DOF=965 P value=0.7793
Variable #302 SBI new and #216 Carbon Tet external
Spearmans correlation=-0.0363 DOF=965 P value=0.2599
Variable #302 SBI new and #217 Ethyl Benzene ext
Spearmans correlation=-0.0188 DOF=965 P value=0.5590
Variable #302 SBI new and #218 ETS ext
Spearmans correlation=-0.0407 DOF=956 P value=0.2076
Variable #302 SBI new and #219 Fungi ext
Spearmans correlation=-0.0191 DOF=971 P value=0.5525
Variable #302 SBI new and #220 HCHO ext
Spearmans correlation=-0.0772 DOF=971 P value=0.0160
Variable #302 SBI new and #221 Mpxylene ext
Spearmans correlation=-0.0209 DOF=965 P value=0.5171
Variable #302 SBI new and #222 NO2 ext
Spearmans correlation=-0.0422 DOF=971 P value=0.1880
Variable #302 SBI new and #223 O3 ext
Spearmans correlation=-0.0559 DOF=971 P value=0.0811
Variable #302 SBI new and #224 ODichloro ext
Spearmans correlation=-0.0014 DOF=965 P value=0.9657
Variable #302 SBI new and #225 OXylene ext
Spearmans correlation=-0.0530 DOF=965 P value=0.0998
Variable #302 SBI new and #226 RSP ext
Spearmans correlation=-0.1073 DOF=971 P value=0.0008
Variable #302 SBI new and #227 Tetrachloroeth ext
Spearmans correlation=0.0803 DOF=971 P value=0.0122
Variable #302 SBI new and #228 Toluene ext
Spearmans correlation=-0.0287 DOF=950 P value=0.3770
Variable #302 SBI new and #229 Trichloro ext
Spearmans correlation=-0.0906 DOF=965 P value=0.0048
Variable #302 SBI new and #230 Bacteria
Spearmans correlation=0.0504 DOF=721 P value=0.1760
Variable #302 SBI new and #231 Benzene
Spearmans correlation=0.0299 DOF=848 P value=0.3834
Variable #302 SBI new and #232 Choloro

PM3006517552
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Spearmans correlation=0.0898 DOF=848 P value=0.0088
Variable #302 SBI new and #233 Carbon Tet
Spearmans correlation=0.1153 DOF=848 P value=0.0008
Variable #302 SBI new and #234 Ethyl Benzene
Spearmans correlation=0.0321 DOF=848 P value=0.3493
Variable #302 SBI new and #235 ETS
Spearmans correlation=-0.0210 DOF=607 P value=0.6054
Variable #302 SBI new and #236 Fungi
Spearmans correlation=-0.0444 DOF=738 P value=0.2276
Variable #302 SBI new and #237 HCHO
Spearmans correlation=-0.1423 DOF=731 P value=0.0001
Variable #302 SBI new and #238 Mpxylene
Spearmans correlation=-0.0012 DOF=848 P value=0.9712
Variable #302 SBI new and #239 NO2
Spearmans correlation=-0.0538 DOF=738 P value=0.1437
Variable #302 SBI new and #240 O3
Spearmans correlation=-0.0230 DOF=739 P value=0.5327
Variable #302 SBI new and #241 ODichloro
Spearmans correlation=-0.0355 DOF=848 P value=0.3011
Variable #302 SBI new and #242 OXylene
Spearmans correlation=-0.0174 DOF=848 P value=0.6128
Variable #302 SBI new and #243 RSP
Spearmans correlation=-0.0771 DOF=738 P value=0.0361
Variable #302 SBI new and #244 Tetrachloroeth
Spearmans correlation=-0.0067 DOF=848 P value=0.8452
Variable #302 SBI new and #245 Toluene
Spearmans correlation=-0.0471 DOF=845 P value=0.1709
Variable #302 SBI new and #246 Trichloro
Spearmans correlation=0.0548 DOF=848 P value=0.1103

PM3006517553
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX IX

Example of SQL Database

PM3006517554

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

In the 'Select Query Item' window, user can choose to display more than one item in the IAQ Query Table. For example, if the Building Name, Survey Date, Study Area, Study Time and pollutants CO_2 have been chosen, the information would be displayed on the 'IAQ Query' Table as in Figure IX-1.

IAQ Query

	Building Name	Survey Date	Study Area	Real Time	CO2
36	Cheung Sha Wan Plaza	5/20/96	4	4:25:00 PM	1456
37	Cheung Sha Wan Plaza	5/20/96	5	10:23:00 AM	1032
38	Cheung Sha Wan Plaza	5/20/96	5	11:13:00 AM	1222
39	Cheung Sha Wan Plaza	5/20/96	5	11:33:00 AM	1304
40	Cheung Sha Wan Plaza	5/20/96	5	12:10:00 PM	1297
41	Cheung Sha Wan Plaza	5/20/96	5	12:31:00 PM	1292
42	Cheung Sha Wan Plaza	5/20/96	5	1:24:00 PM	1241
43	Cheung Sha Wan Plaza	5/20/96	5	2:33:00 PM	1192
44	Cheung Sha Wan Plaza	5/20/96	5	3:36:00 PM	1333
45	Cheung Sha Wan Plaza	5/20/96	5	4:30:00 PM	1344
46	China Building	8/29/96	1	9:41:00 AM	798
47	China Building	8/29/96	1	10:36:00 AM	727
48	China Building	8/29/96	1	11:24:00 AM	798
49	China Building	8/29/96	1	12:28:00 PM	757
50	China Building	8/29/96	1	1:46:00 PM	760
51	China Building	8/29/96	1	2:40:00 PM	800
52	China Building	8/29/96	1	3:32:00 PM	820
53	China Building	8/29/96	1	4:31:00 PM	863
54	China Building	8/29/96	2	10:08:00 AM	613
55	China Building	8/29/96	2	10:53:00 AM	691
56	China Building	8/29/96	2	11:51:00 AM	668
57	China Building	8/29/96	2	12:49:00 PM	752
58	China Building	8/29/96	2	2:03:00 PM	711
59	China Building	8/29/96	2	2:56:00 PM	762
60	China Building	8/29/96	2	4:07:00 PM	808

Figure IX-1: IAQ Query Table

Since the two buildings 'CSW Plaza' and 'C Building' have been chosen graphically from the Hong Kong map on VHGIS platform, it becomes a criteria to query the IAQ data. It instructs the system to sort out the building name, survey date, study area, study time and the CO_2 concentration which the building name is equal to 'CSW Plaza' or 'C Building'.

The IAQMIS is a multi-query system because user can further set the query criteria base on the existing criteria. User can add or delete the query building from the VHGIS platform or from the 'Filtering Criteria Definition' Table (Figure IX-2). If the user want to analyse the information from 'C Building' only, user can do it by deleting the building name equal to 'CSW Plaza' from the 'Filtering Criteria Definition' Table. The filtering criteria would automatically update the criteria as shown in Figure IX-3.

PM3006517555

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

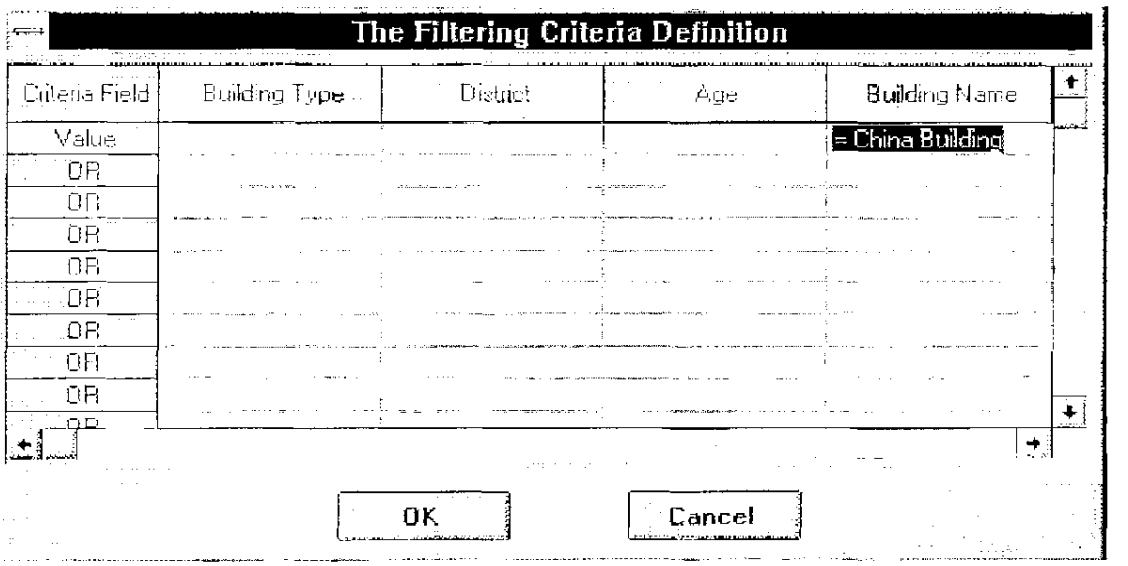


Figure IX-2: The Filtering Criteria Definition Table

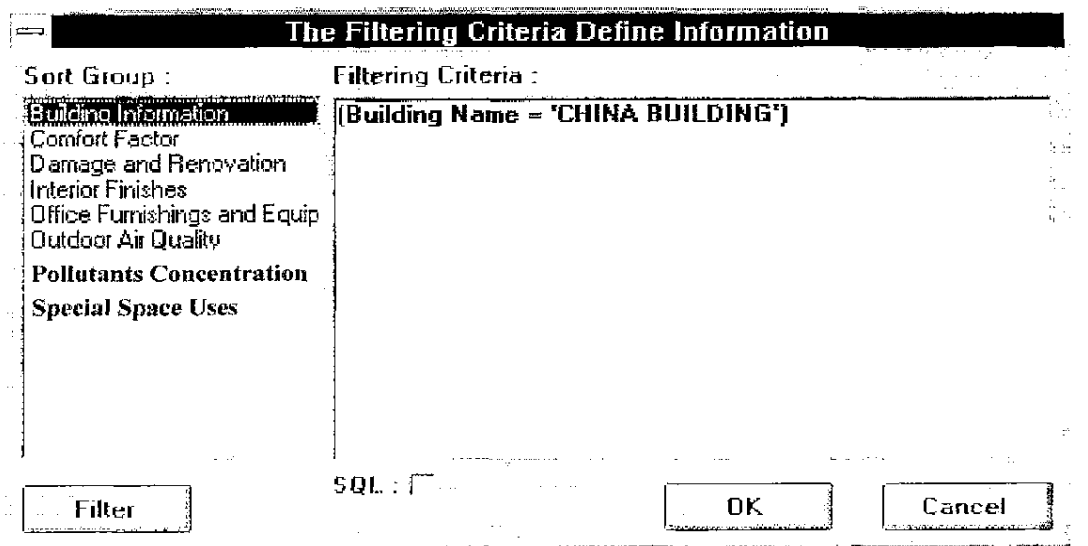


Figure IX-3: Window of Filtering Criteria Define Information

The IAQMIS system can modify not only the query criteria, but also the number of fields displayed. For example, if the user wants to see the RSP concentration based on the above query criteria, it can be done by selecting the RSP item from the IAQ Data Selection Table. The IAQ

PM3006517556

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Query Table would automatically display the RSP items together with the original selected fields. (Figure IX-4)

IAQ Query

	Building Name	Survey Date	Study Area	Real Time	CO	RSP
1	China Building	8/29/96	1	9:41:00 AM	1090	0.034
2	China Building	8/29/96	1	10:36:00 AM	837	0.026
3	China Building	8/29/96	1	11:34:00 AM	777	0.026
4	China Building	8/29/96	1	12:28:00 PM	639	0.019
5	China Building	8/29/96	1	1:46:00 PM	785	0.023
6	China Building	8/29/96	1	2:40:00 PM	870	0.02
7	China Building	8/29/96	1	3:32:00 PM	1040	0.024
8	China Building	8/29/96	1	4:31:00 PM	1030	0.023
9	China Building	8/29/96	2	10:08:00 AM	862	0.025
10	China Building	8/29/96	2	10:53:00 AM	803	0.022
11	China Building	8/29/96	2	11:51:00 AM	524	0.021
12	China Building	8/29/96	2	12:49:00 PM	579	0.024
13	China Building	8/29/96	2	2:03:00 PM	697	0.026
14	China Building	8/29/96	2	2:56:00 PM	823	0.023
15	China Building	8/29/96	2	4:07:00 PM	986	0.028
16	China Building	8/29/96	2	4:45:00 PM	995	0.027
17	China Building	8/29/96	3	9:55:00 AM	1010	0.021
18	China Building	8/29/96	3	10:41:00 AM	717	0.019
19	China Building	8/29/96	3	11:35:00 AM	706	0.02
20	China Building	8/29/96	3	12:36:00 PM	567	0.019
21	China Building	8/29/96	3	1:52:00 PM	746	0.018
22	China Building	8/29/96	3	2:44:00 PM	749	0.02
23	China Building	8/29/96	3	3:36:00 PM	1010	0.022
24	China Building	8/29/96	3	4:35:00 PM	1040	0.017
25	China Building	8/29/96	4	10:14:00 AM	925	0.023

Figure IX-4: IAQ Query Table with RSP Concentration

PM3006517557

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX X

Human Exposure Index : Values for Calculations

PM3006517558

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

X-1 *List of URF Values (Risk Factor)*

Substance	URF ($\mu g^{-1}m^{-3}$)
Benzene	$2.9*10^{-5}$
Carbon tetrachloride	$4.2*10^{-5}$
Chloroform	$5.3*10^{-5}$
Tetrachloroethylene	$5.9*10^{-6}$
Trichlorethylene	$2.0*10^{-6}$
Formaldehyde	$6.0*10^{-6}$
Environmental tobacco smoke[1] (ETS)	$2.8*10^{-5}$

Note:

[1] is preliminary value from OEHHA & US EPA (CAPCOA, 1993)
Source: CAPCOA , 1993

X-2 *Reference Exposure Levels*

Substance	REL ($\mu g / m^3$) (inhalation)
Benzene	7.1*10
Carbon tetrachloride	{2.4}
Chloroform	{3.5*10}
Tetrachloroethylene	{3.5*10}
Toluene	$2.0*10^2$
Trichlorethylene	$6.4*10^2$
m,p, o-Xylene*	$3.0*10^2$
Ozone	$1.8*10^2$
Formaldehyde	{3.6}
Nitrogen Dioxide	$4.7*10^2$

Note:

* - value given is for Xylenes
{ } - converted from oral acceptable exposure levels (CAPCOA, 1993)
Source: - CAPCOA , 1993

PM3006517559
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

X-3 *Toxicological Endpoints*

Substance	CV/BL	CNS/PNS	IMMU	KID	GI/LV	REPR	RESP
Benzene		X					
Carbon tetrachloride					X		
Chloroform					X		
Tetrachloroethylene				X	X		
Toluene		X				X	
Trichlorethylene		X			X		
m,p-Xylene						X	X
o-Xylene						X	X
Ozone							X
Formaldehyde							X
Nitrogen Dioxide							X

Note:
X - each chemical affecting the target organ
CV/BL - cardio-vascular system; blood & circulatory system) not
IMMU - immune system) affected
CNS/PNS - central nervous system; peripheral nervous system
KID - kidneys
GI/LV - gastro-intestinal; liver
REPR - reproductive system
RESP - respiratory system

Source: CAOCOA, 1993

PM3006517560

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX XI

An Example of How to Run IAQSim V1.0

PM3006517561

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Figure XI-1 below shows: the dialogue box for entering map name, audit ID, password, floor plan size and choosing floor plan template.

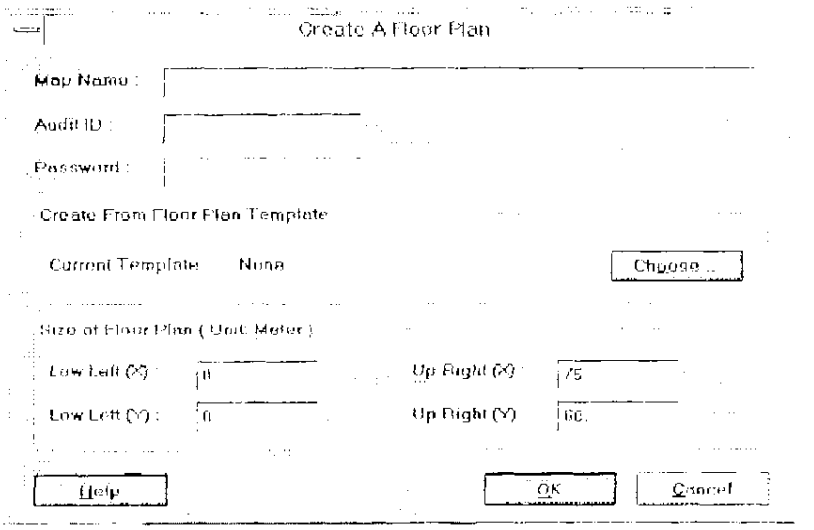


Figure XI-1 The Dialogue Box for Creating a New Floor Map.

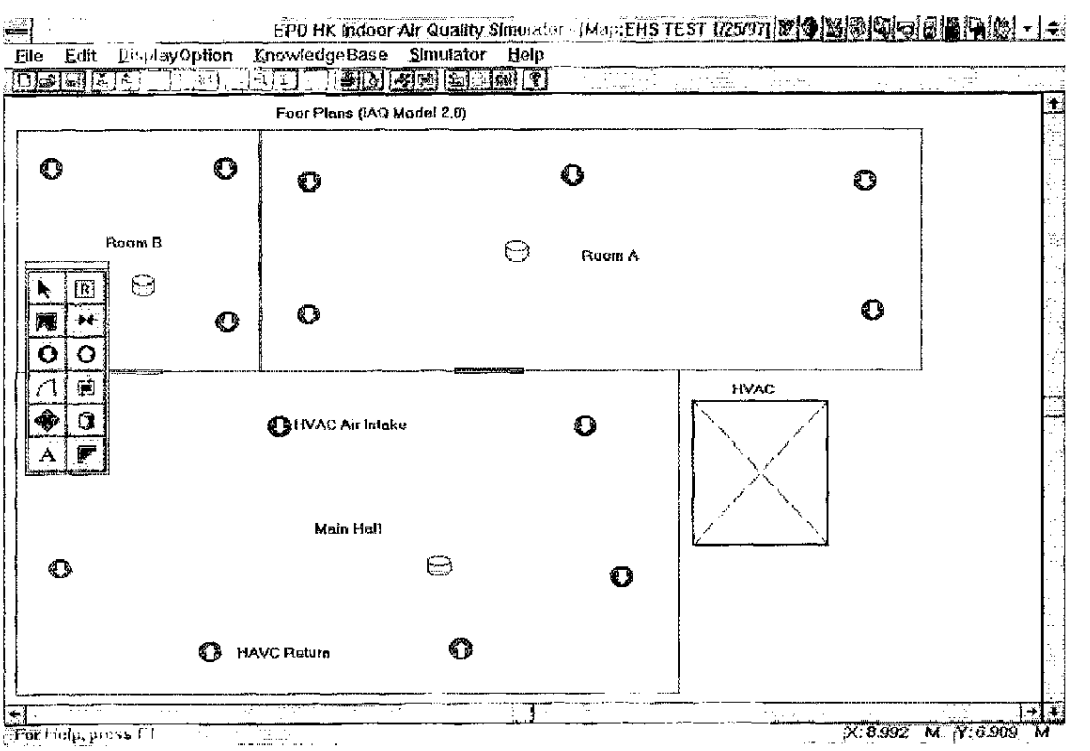


Figure XI-2: An Example of a Floor Plan of IAQ.Sim 1.0 Model

PM3006517562

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

After entering the information as required in "Create A Floor Plan" dialogue box, the user can begin to locate the IAQ related objects on the plan as shown in Figure XI-2.

In this example, a floor plan named "EHS Test" has been created. Attributes of each IAQ related object in the room on the plan can be edited and defined separately.

For pollutant sources, sinks and cleaners, the user performing the simulation is required to specify the frequency and other relevant estimates, including identifying the type and schedule of the operation of these objects.

Enter of detailed information of the HVAC system can be modified by the user, which includes the air flow rates, fraction of makeup air, size of air inlets and outlets and operation schedule.

After defining all IAQ attributes for the related objects on the floor plan, the user can update the information in: i) the pollutant database, and ii) the sink and air cleaner database, as shown in Figure XI-3 and Figure XI-4 respectively.

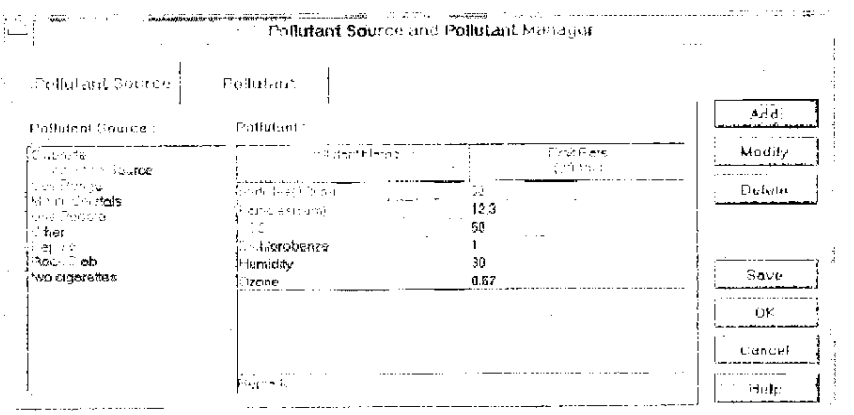


Figure XI-3: Pollution Source and Pollutant Manager

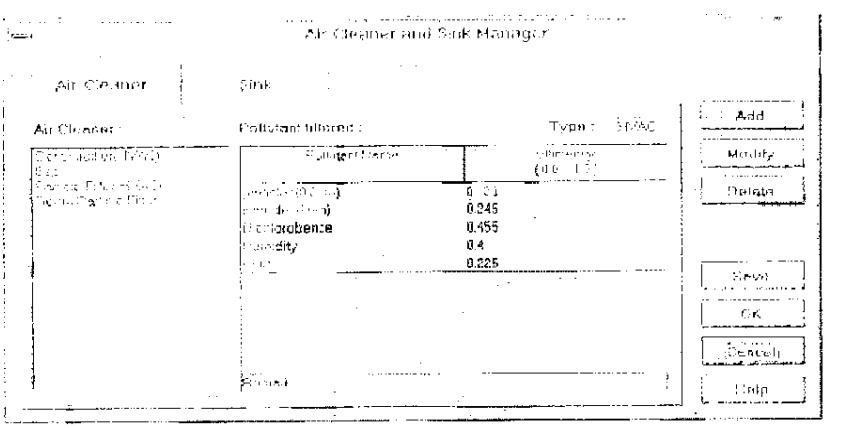


Figure XI-4 Air Cleaner and Sink Manager

PM3006517563

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Before the user can actually run the simulation, the programme requires the user to set up a run code. The runcode contains information about the simulating period, initial pollutant concentration and pollutants to be simulated. Figure XI-5 shows an example of the run code called "Test Code".

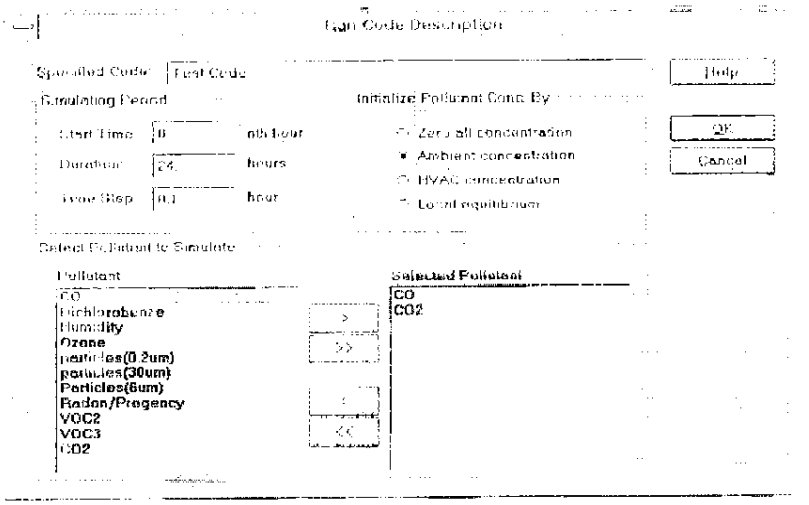


Figure XI-5 To Run Test Code

At this stage, the user can start the "Simulator" of IAQ.SIM model.

To view the pollution concentration report, the user has to choose the "Report" function and identify the room and pollutant required as shown in Figure XI-6.

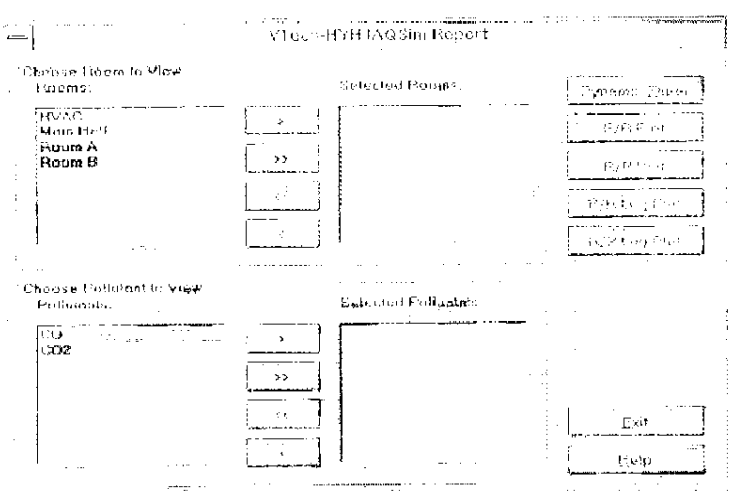


Figure XI-6 IAQSIM Report Dialogue Box

PM3006517564

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

Figure XI-7 shows an example of the simulated concentration report by the IAQ.SIM V1.0 model.

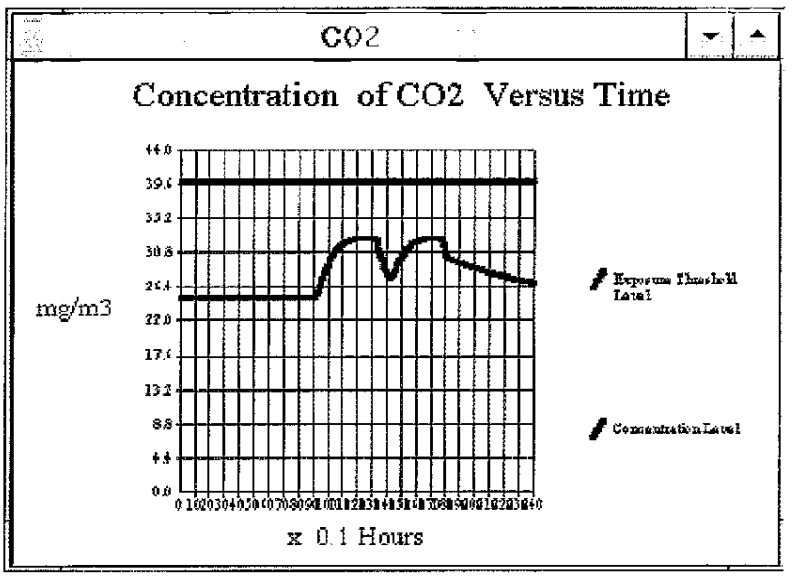


Figure XI-7 An Example of IAQSIM Concentration Report

In the next stage, a Health Risk Assessment can be made according to the concentrations simulated. First, the user has to set the work period for each day, the number of work days per year and working years per lifetime for a person as in Figure XI-8.

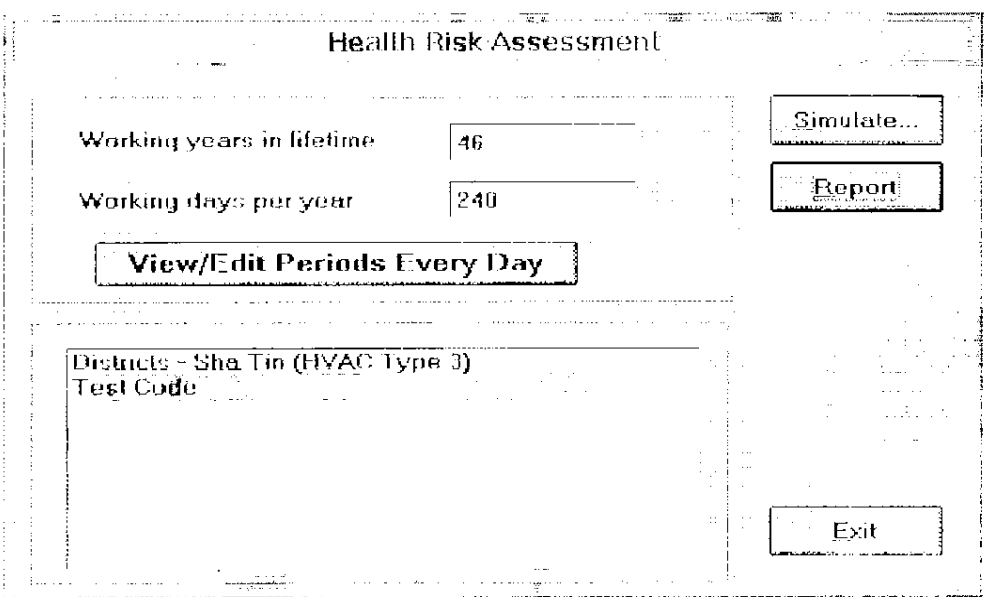


Figure XI-8 Dialogue Box for Health Risk Assessment

PM3006517565
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

After simulation, the report for Health Risk Assessment can be displayed as in Figure XI-9. In the dialogue box, data on Lifetime Cancer Probability, Hazard Quotient, Hazard on Toxicological Endpoints Affected and Human Exposure Index are contained in different folders.

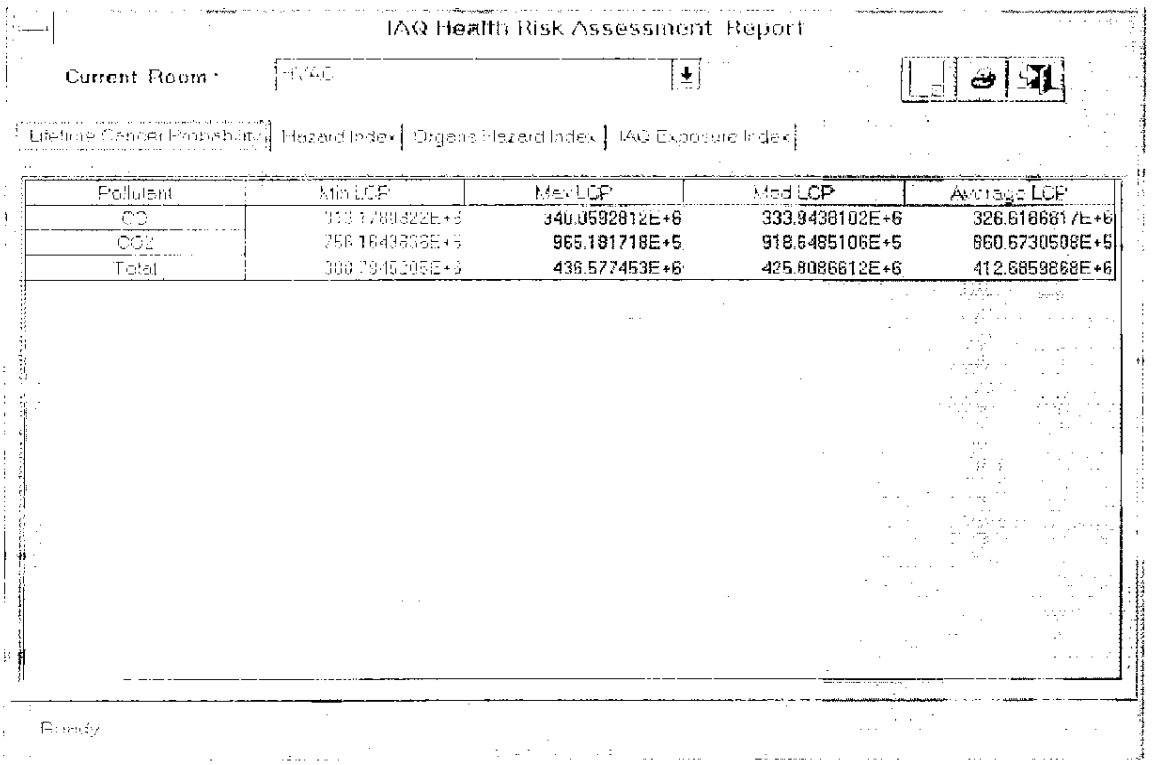


Figure XI-9 Dialogue Box for Health Risk Assessment

PM3006517566

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX XII

Significant Percentile of Indoor Air Pollutants

PM3006517567

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

XIIa : Summary of Indoor Pollutant Levels Recorded from the 40 Offices During The Summer Survey

Pollutant	IAQ-O (8 hrs)	Unit	High	Low	Mean	SD	50 percentile	75 percentile	95 percentile
CO	10,000	$\mu g/m^3$	1958.91	233.02	854.25	456.57	744.12	1102.4	1809.78
CO_2	1,000	ppm	1816.03	506.33	958.63	276.56	866.94	1082.74	1506.25
HCHO	100	$\mu g/m^3$	176.98	20.86	71.28	41.70	63.92	105.52	132.24
NO_2	150	$\mu g/m^3$	49.63	4.20	18.97	10.92	15.42	25.26	39.28
O_3	120	$\mu g/m^3$	124.62	27.48	37.32	20.25	27.48	38.50	82.83
RSP	180	$\mu g/m^3$	163.57	6.75	29.74	24.15	24.04	34.97	51.64
Nicotine	6.8	$\mu g/m^3$	5.26	0.95	1.438	1.15	0.95	0.95	3.95
Benzene	48.75	$\mu g/m^3$	102.09	0.32	6.57	15.24	3.03	5.98	16.99
Carbon tetrachloride	1,600	$\mu g/m^3$	2.05	0.63	0.78	0.30	0.63	0.79	1.26
Chloroform	2,500	$\mu g/m^3$	2.43	0.21	0.52	0.51	0.28	0.57	1.78
o-dichlorobenzene	7,500	$\mu g/m^3$	4.21	0.60	1.08	0.75	0.75	1.20	2.65
m-dichlorobenzene	7,500	$\mu g/m^3$	22.70	0.60	2.79	4.27	0.80	3.00	11.91
p-dichlorobenzene	3,000	$\mu g/m^3$	72.45	0.60	14.03	16.84	6.77	14.13	51.59
Ethyl benzene	21,750	$\mu g/m^3$	455.22	0.43	20.45	70.11	3.58	9.45	85.08
Tetrachloroehtylene	5,000	$\mu g/m^3$	15.95	0.68	2.95	3.41	1.53	3.06	10.19
Toluene	7,600	$\mu g/m^3$	3113.70	4.05	247.76	598.51	56.72	150.98	1294.40
Trichloroethylene	1,000	$\mu g/m^3$	995.00	0.54	29.15	149.13	1.21	3.23	42.68
o-xylene	21,700	$\mu g/m^3$	216.77	0.87	14.91	37.30	4.55	7.37	66.87
m,p-xylene	21,700	$\mu g/m^3$	586.36	0.43	35.91	94.97	9.97	16.80	167.35
Bacteria	1,000	cfu/m^3	2777.33	38.67	739.15	541.57	598.67	959.0	1680.33
Fungi	500	cfu/m^3	1414.67	13.5	186.88	270.96	86.17	194.67	482.47

PM3006517568

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

XIIb : Summary of Indoor Pollutant Levels Recorded from the Public Places During The Summer Survey

			Restaurant			Cinema			Shopping Mall		
Pollutant	IAQ-O (1 hr)	Unit	High	Low	Mean	High	Low	Mean	High	Low	Mean
CO	30,000	$\mu g/m^3$	6739.34	905.34	3344.87	3487.93	938.61	1695.87	3180.70	766.56	1659.50
CO_2	1,000*	ppm	1921.71	754.41	1271.63	2369.00	546.26	1362.12	1371.00	716.06	1002.60
HCHO	100	$\mu g/m^3$	975.18	20.86	161.73	463.95	20.86	139.36	57.15	23.98	38.84
NO_2	200	$\mu g/m^3$	279.42	29.78	133.16	134.11	22.87	66.10	98.29	38.03	63.64
O_3	240	$\mu g/m^3$	367.25	27.48	54.36	27.48	27.48	27.48	93.32	27.48	38.46
RSP	180*	$\mu g/m^3$	1070.06	53.14	323.0	64.74	43.16	54.97	110.66	38.40	77.89
Nicotine	6.8*	$\mu g/m^3$	56.23	0.95	7.40	0.95	0.95	0.95	3.18	0.95	1.95
Benzene	as low as possible	$\mu g/m^3$	31.9	0.32	12.23	2.87	0.32	1.85	10.21	2.08	5.78
Carbon Tetrachloride	4,000	$\mu g/m^3$	1.26	0.63	0.69	2.52	0.63	1.26	0.79	0.63	0.65
Chloroform	10,000	$\mu g/m^3$	10.74	0.21	1.86	1.24	0.21	0.66	0.83	0.21	0.47
o-Dichlorobenzene	15,000	$\mu g/m^3$	6.61	0.60	1.26	6.61	0.60	2.04	5.56	0.60	1.69
m-Dichlorobenzene	15,000	$\mu g/m^3$	3.61	0.60	0.87	6.01	0.60	1.80	3.31	0.60	1.54
p-Dichlorobenzene	3,000*	$\mu g/m^3$	37.88	1.80	11.60	42.09	1.80	12.14	36.98	1.65	13.88
Ethylbenzene	27,250	$\mu g/m^3$	29.05	0.43	7.74	11.27	1.30	3.81	20.48	1.19	8.29
Tetrachloroethylene	8,000	$\mu g/m^3$	31.23	0.68	5.60	5.43	0.68	1.63	7.47	0.68	1.89
Toluene	14,000	$\mu g/m^3$	451.53	4.14	104.08	8.65	6.02	7.60	232.35	9.79	85.88
Trichloroethylene	2,000	$\mu g/m^3$	3.23	0.54	1.02	1.08	0.54	0.65	13.85	0.54	2.74
o-xylene	32,550	$\mu g/m^3$	41.62	0.43	8.63	25.58	0.43	6.42	16.69	1.63	7.55
m,p-xylene	32,550	$\mu g/m^3$	82.37	2.6	22.85	69.37	1.73	17.86	54.09	3.25	18.75
Bacteria	1,000*	cfu/m^3	2275.00	125.00	1002.78	856.00	69.00	430.00	4891.00	465.33	2140.06
Fungi	500*	cfu/m^3	200.00	6.00	77.11	44.00	6.00	26.20	1161.00	77.00	376.54

abbreviation:

* 8-hour IAQ objective

PM30065175 69

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

APPENDIX XIII

Cost Estimates for IAQ Improvement
and
Organisational Structure of Indoor Air Quality Management Group

PM3006517570

Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

XIII- 1 Salary Breakdown for Hong Kong Employees and Estimated Loss

Occupation	HK$	Persons	Total HK$ (million)
Managers and Administrators	20,000	247,600	4,952
Professionals	25,000	141,000	3,525
Associate professionals	14,000	391,300	5,478.2
Clerks	9,000	540,200	4,861.8
Service workers and shop sales workers	8,500	408,800	3,474.8
Craft and related workers	9,000	345,000	3,105
Plant and machine operators and assemblers	9,000	320,900	2,888.1
Elementary occupations	5,500	496,800	2,732.4
Others	6,000	13,600	81.6
	Total	2,905,200	
		Total	31,098.9
Loss in salary		3%	932.97 (~ 1 billion)
On an annual basis			~ 12 billion

Employed persons by occupation, 1995
Census and Statistics Department (Ref. (82) in CENST 8035/1 XX)

XIII- 2 Capital Costs

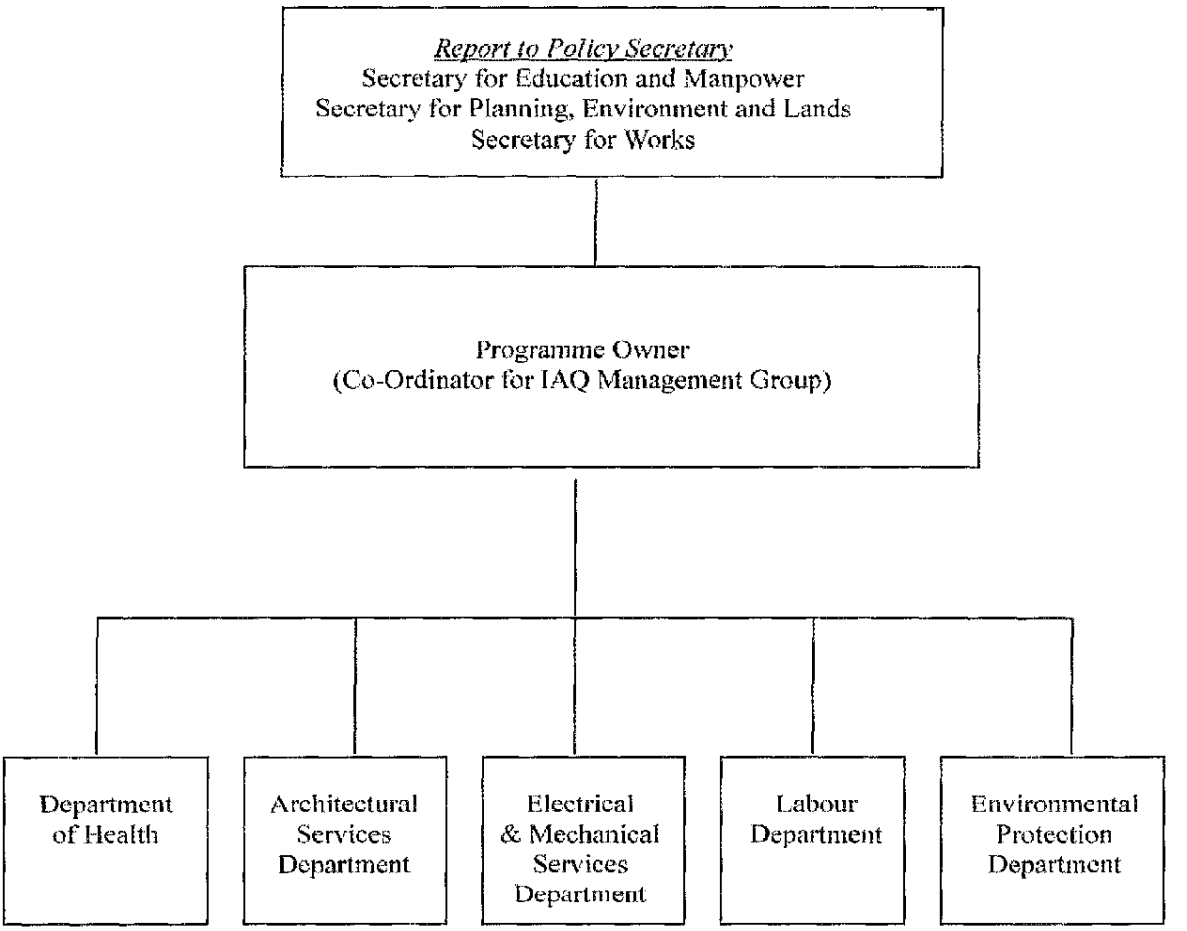
MVAC	Cost (HK$)	Total (HK$ - million)
Air-conditioning system upgrade for 7.2 million m^2 space	15,000 (for 200 m^2)	540
Air-conditioning system upgrade for restaurants (general) 30% of 9000 total	20,000 (per restaurant)	60
Air-conditioning system upgrade for shopping malls (large scale) for 50 sites	50,000 (per site)	2.5
Sub-total		602.5
Amortized over 5 years, subtotal		0.12 billion

XIII- 3 Recurring Expenses

	Recurring Expenses	Cost per month/ per unit (HK$)	Total Cost per year (HK$ - million)
1.	Increase in electricity costs in office premises	500 (200 m^2)	216.0
2.	Restaurants (3000 nos.)	700	25.2
3.	Shopping malls (50 nos.)	20,000	12.0
4.	Costs in laboratory testing for restaurants at license renewal	10,000	30.0
5.	Costs in training and supervising IAQ for companies >50) (approx. 400)	5,500	26.4
	Sub-Total		309.6
	Total		0.43 billion

PM3006517571
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001

XIII- 4 Organisational Structure of IAQ Management Group



Other relevant departments include:
Fire Services Department
Agriculture & Fisheries Department
Buildings Department
Customs and Excise Department
Urban Services Department

PM3006517572
Source: https://www.industrydocuments.ucsf.edu/docs/jrgj0001